The Foundry Trade Journal

AND

PATTERN-MAKER.

THE OFFICIAL ORGAN OF THE BRITISH FOUNDRYMEN'S ASSOCIATION.

Vol. 10. SEPTEMBER, 1908. No. 81.

——PUBLISHED——
THE FIRST WEEK IN EACH MONTH BY

EAGLAND & Co., Ltd.
165, STRAND, LONDON, W.C.

Subscription Terms: 7s. 6d. per annum, post free.
To place the "Journal" within the reach of Working Moulders and Pattern-makers the Proprietors will accept subscriptions, not less than three in number from one shop, at the reduced rate of 5/- per annum, such order to be countersigned by the superintendent or foreman.

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THE FOUNDRY TRADE JOURNAL,
165, Strand, London, W.C.

BRITISH FOUNDRYMEN'S ASSOCIATION.

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NOTES AND COMMENTS.

The British Foundrymen's Convention.

The annual Convention of the British Foundrymen's Association, with its accompanying report of the past year's work, shows that the officers have good reason to be pleased with the progress made. It is five years since the formation of the Association, and the members at present number 320. When this membership is compared with the number of foundries in the kingdom it does not seem very imposing, but it must be remembered that the Branches are only few in number, while the foundries are situated in every district of the country. The benefits of membership are essentially those which result from the meetings and discussions on foundry topics, and a limitation in the number of Branches means a limitation in the number of men who can be touched. The influence of the Association and the appreciation of its objects is spreading rapidly, however, and soon we shall probably see Branches established in every large founding centre. The good work of the officers during the past year, and the ardour displayed by the members attending at Newcastle-on-Tyne last month, speaks well for the maintenance of the progressive spirit which has characterised the Association from its inception. Strange to say, it is the support of the practical foundryman at the meetings, and not of the scientist and metallurgist, which is remarked on as being somewhat behind. Perhaps, after all, this is not to be wondered at, for the foundryman's work is not of the sort to cultivate lecture-room capabilities. The most intelligent and capable men in the foundry often find it difficult to lay their experience before their fellow workers in the lecture-room; but this fault will be overcome with the establishment of the spirit of *camaraderie* which the Association aims at. Already we find the scientist and the foundryman exchanging opinions freely, and as freely criticising each other's views—which is as it should be.

Forbidden Topics.

It is only natural that this free interchange of opinion between the members should lead sometimes to subjects being raised which, it is generally agreed, had better be tabooed by a technical association. Many subjects such as those dealing with Trade Unions, while touching closely on shop management and labour organisation, are rather dangerous topics, and we can only agree with the dictum of Mr. Pilkington that there is scope enough for their endeavours apart from such subjects. In any gathering of commercial men and workers there are sure to be many strong partisans of both sides.

The New Brass Casting Regulation.

The new regulations recently issued by the Home Office, which were published in these columns last month, have met with general approval from the workers. The Secretary of the National Society of Amalgamated Brassworkers, in the course of an interview, said he was satisfied with the new code of regulations, and had great hopes of them effecting much improvement in the conditions of the industry. The regulations were more favourable to the workpeople than were the modified provisions to which he himself agreed in the private conference with the representative employers in Birmingham during the Home Office enquiry. Unless employers instal some patent appliance such as Lynes's apparatus, he thinks considerable structural alterations will have to be carried out in many Birmingham factories.

The employers, however, are not all quite satisfied, and many suggest that too many responsibilities and restrictions are being placed upon the manufacturer. A contemporary goes so far as to say that we are apparently almost within sight of the time when some of our industries may be inspected out of existence. The same journal says it is doubtful if there exists any shop in which the casting of cabinet brass-foundry is carried on that contains so large a cubic area as 2,500 ft. or more. The regulation as regards washing will also, it is claimed, be found irksome. So much for that point of view, and there is a good deal to be said for both sides; but is it not an eloquent comment on the conditions under which brass-casting is now being carried on to admit that these regulations, which are issued in the interests of healthy conditions for the worker, will have such a general effect, and be so generally applicable to existing foundries?

MALLEABLE IRON CASTINGS.*

By C. H. Gale.

Malleable iron is melted in the reverberatory furnace, the open-hearth furnace and the cupola. The reverberatory furnace is the most extensively used, about 85 per cent. of the entire output of the United States being melted by this process. But little change has been made in this type of furnace since its adoption by the earlier manufacturers, beyond a marked increase in capacity. Prior to about 1885 the standard furnace was one of five tons capacity. This has been increased from time to time, until at the present time we have furnaces of 25 and 30 tons capacity, though furnaces of from 10 to 15 tons capacity are the most popular, and give more uniform results than those of larger capacity.

The adoption of the open-hearth furnace for malleable iron dates back about 15 years. This type of furnace is now used largely and successfully in this district, more than 50 per cent. of the malleable iron made by the open-hearth furnace being produced in the Pittsburgh District. This success, which has not always followed the introduction of this furnace in the malleable foundry, can be attributed to the local familiarity with this type of furnace from its extensive use in the steel mills.

A Comparison of the Different Types of Furnace.

The open-hearth furnace has many advantages over the reverberatory furnace, especially where the output is large, and orders guarantee a long, steady run, the chief advantages being cost of repairs and period of operation. A run of 300 to 400 heats without the loss of a single day for repairs is not uncommon. Then will come a shut-down of a week's duration for minor repairs and cleaning out, putting the furnace in condition for another like run. This long, uninterrupted run, to the operator of the reverberatory furnace, when customers are calling for deliveries, and who at the most can get but a week of uninterrupted service, or 12 to 18 heats from his furnace, seems like the dawn of the millennium.

After 1,200 or more heats the open-hearth furnace will need a general repair requiring four or five weeks, and here in the length of time required to make these repairs is where the reverberatory furnace has the advantage, it being a

* A Paper read before the Pittsburg Foundrymen's Association.

not uncommon practice during a busy season to rebuild the side walls, repair bridge walls, and put in an entirely new bottom with the loss of one or at most two day's time. During a very busy season these repairs are frequently made on Sunday, thus avoiding the loss of a working day. Moreover, the reverberatory furnace can be charged within a few hours after these repairs are completed, while the open-hearth furnace requires as many days to be brought to the required temperature before receiving the charge.

A heat of iron, after being melted and brought to the proper condition for casting, can be held in the open-hearth furnace without injury for a much longer period than in the reverberatory furnace, not being subjected to the intense oxidising flame of the latter, especially that produced by the use of the top blast.

Cupola melted iron does not possess the tensile strength nor ductility of iron melted in the reverberatory or open-hearth furnace, due partly to the higher carbon and sulphur caused by the metal being in contact with the fuel. This feature is rather an advantage than otherwise, as most of the product of cupola melted iron consists of pipe fittings—castings that are not subjected to any great stress or shock. These castings are threaded, and a strong, tough malleable iron does not cut a clean, smooth thread, but rather will rough up under the cutting tool.

The Annealing Process.

The annealing process for malleable castings differs from that of steel castings in that in the case of steel when recalescence, or the refining temperature, has been safely reached, it is needless or rather unwise to prolong the heat, while in malleable iron the annealing process has at this period but begun. This heat must be maintained for from two to four days, depending upon the thickness of sections of the castings under treatment, and the compactness with which the castings or annealing boxes are placed in the furnace. The annealing temperature, 1,550 to 1,600 degrees F., is, however, not absolutely essential to thoroughly anneal malleable iron. This can be accomplished at a temperature as low as 1,300 degrees, but the time required will be at least twice that of the higher temperature.

There are but few concerns engaged in the business for any considerable time with whom there has not been tried out the process of annealing without surrounding the castings with a packing material, but the heavy scale formed on the castings, and their general unsightly appearance, together with a refusal of acceptance on the part of the customer, soon convinces the experimenter of the folly of continuing the process. Malleable castings can be annealed without the aid of any packing material and still preserve their appearance, and without the formation of scale by placing them in an airtight receptacle excluded from the flame and gases in the furnace; however, as economy of production is the objective point sought, this process has nothing to commend it.

Material for Packing the Castings.

Until recent years the material in which castings were packed for annealing was composed of hammer and rolling mill scale, turnings, borings, etc. This was treated with a solution of sal-ammoniac or muriatic acid to form a heavy coating of oxide. This method has, however, been nearly superseded by the use of slag. The slag that is skimmed from the bath of the melting furnace, when ground to pea size and smaller in a tumbling barrel, makes an excellent packing material. Care should be taken to cool this slag with water as it is being skimmed from the melting furnace, it being the custom in some foundries to use old sand with which to deaden the heat. Better results can be obtained from this slag in the annealing furnace if kept quite free from sand and dirt.

Many malleable foundries in the vicinity of blast furnaces, where granulated slag can be had at a small cost, use this for annealing, it being probably the most economical. Fire-sand and fire-clay are also used, fire-sand being an excellent material where the castings are very light and of intricate shape. Such castings, when packed in sand, will retain their shape, even though the furnace be overheated. This sand, however, deteriorates very rapidly if not renewed. Experiments conducted without the addition of new sand gives the following results:—First and second times of using gave good, well-annealed castings; third and fourth times of using gave castings with a fair anneal, but showed a tendency to weakness; fifth time showed a still weaker casting, while the sixth and seventh times the sand was used produced castings of but little more strength than the original hard iron, and they had to be returned for re-annealing. After the seventh time of using the sand resembled a heavy wood ash.

The theory of oxidising the scale and borings that was adhered to so long was that the castings would become decarbonised by the oxygen in the packing material combining with the carbon in the castings, the large percentage of iron oxide in the furnace slag, about 50 per cent., being the principle that first led to its substitution for scale and borings, but that the presence of a large percentage of this oxide is not essential is proved by the results obtained when annealing with materials containing little or no oxide. Many malleable foundries where scale and borings are still used have discontinued the oxidising of this material with sal-ammoniac or acids.

Physical Characteristics.

The physical characteristic that gives malleable iron its greatest value, and wherein it differs from grey iron, lies in its ability to resist shocks and an increased tensile strength. The degree of malleability in light and heavy castings varies. In a light casting $\frac{1}{4}$ in. thick and less, it means a soft, pliable condition, and the ability to withstand considerable distortion without fracture, while in the heavy sections, $\frac{1}{2}$ in. and over, it means the ability to resist shocks without bending or breaking.

The tensile strength of malleable iron varies with the thickness of the metal, the lighter sections having a greater strength per square inch than the heavier sections. This fact is now being recognised by engineers, and at least one Eastern railroad, which requires its malleable castings made in accordance with specifications, designates the tensile strength desired in its castings to be as follows:—Sections $\frac{3}{8}$ in. thick or less should have a tensile strength of not less than 40,000 lbs. per square inch; those of $\frac{3}{8}$ to $\frac{3}{4}$ in. thick, not less than 38,000 lbs. per square inch, and those over $\frac{3}{4}$ in. not less than 36,000 lbs. per square inch. In recent tests along these lines, test bars $\frac{5}{8}$ and $\frac{7}{8}$ in. in diameter were made in the same mould and poured from the same ladle, thus ensuring equality of metal, and annealed together. The average tensile strength of five pairs of bars so treated, representing five heats was: $\frac{5}{8}$ in. bars, 45,095 lbs. per square inch; $\frac{7}{8}$ in. bars, 41,316 lbs. per square inch. Average elongation in 6 in.:—$\frac{5}{8}$ in. bars, 5.3 per cent.: $\frac{7}{8}$ in. bars, 4.2 per cent.

A very high tensile strength can be obtained approaching that of cast-steel, but at the expense of the malleability of the product. The writer has seen malleable test bars having a tensile strength of between 60,000 and 70,000 lbs. per square inch, but the ductility and ability to resist shocks of these bars were not equal to that of bars breaking at 40,000 to 45,000 lbs. per square inch.

It was formerly the general belief that the strength of malleable iron was largely in the white skin always found on this material, but it has frequently been demonstrated that the removal of the skin does not proportionately lessen the strength of the casting.

The process of annealing is one of conversion of carbon, there being practically no change in the other elements. The carbon in the original cast state is all in the combined form, this being converted by the heat treatment to graphite. This graphite carbon, however, differs from that present in pig-iron or grey iron castings, a difference that is readily noticed by the chemist. Instead of being present in crystals or grains distributed throughout the metal, it presents itself in an amorphous state, extending through the metal in minute filaments.

Besides the conversion of carbon, there is also a partial elimination of carbon, the loss being greatest in the white skin, the carbon content of which will vary from 0.10 to 0.20, while the interior of the casting will have a total carbon of about 2 per cent. The percentage of loss of carbon is, however, not constant, varying with the material with which the castings are packed for annealing. With a carbonaceous material, as coke, the carbon loss is less than with slag or scale, while castings annealed in coke have a higher sulphur content than before annealing, due to the absorption of this element from the coke.

The following analysis will give a good average of the changes in the elements during the annealing process, slag and coke being used:—

	Si.	S.	P.	Mn.	C.C.	G.C.
Hard iron... ...	0.63	0.043	0.147	0.21	2.54	Trace
Annealed in slag	0.61	0.049	0.145	0.21	0.24	1.65
Annealed in coke	0.61	0.065	0.150	0.21	0.25	2.00

The casting of direct malleable iron, thus eliminating the tedious and expensive annealing process, is a very alluring proposition to the manufacturer, but despite the best efforts of the founder and metallurgist it still remains an iridescent dream, holding in abeyance the fame and fortune of its discoverer until the solution of its fellow problem, the conversion of iron into gold.

British Foundrymen's Association.

The Annual Convention.

The fifth annual Convention of the British Foundrymen's Association was held on Tuesday, August 4, Wednesday, August 5, and Thursday, August 6, at Newcastle-on-Tyne. The meetings for business and discussion were held in the Physics Lecture Theatre of the Armstrong College.

The Auditorium, at the opening session, was filled with members and visitors, and the proceedings throughout were characterised by a lively interest both in the affairs of the Society and in the technical and practical questions which were treated. The papers were of a high standard, and while dealing, in some cases, most minutely with the theory of ferro-metallurgy, commanded attention as being the outcome of experience and observation directed in the course of practice to strictly practical ends.

As at Sheffield last year, the Association was honoured with a civic reception, the Deputy-Lord Mayor and the Sheriff of Newcastle attending in official costume with the escort of sword and mace.

The business sessions were held in the morning. The afternoons were devoted to inspection of works in Newcastle and the neighbourhood, followed by visits to some of the suburbs of the city. The Convention concluded on the Thursday with a visit to Palmer's famous shipbuilding yard at Yarrow and a trip to Durham Cathedral and Castle.

The meetings at the College were presided over at the opening of the first session by Mr. Herbert Pilkington, the retiring President, and subsequently by Mr. F. J. Cook, his successor in the Presidency. Among those attending were:—Messrs. J. E. Stead (Middlesbrough); J. E. H. Allbut (Butterley, Derby); A. Caddick (Messrs. Robeys & Company, Lincoln); Percy Longmuir (Sheffield); F. J. Cook (Birmingham); Robert Buchanan (Birmingham); Douglas G. Cochrane (Middlesbrough); W. Dalrymple (South Shields); Ernest Scott (Newcastle); V. L. Canwell (Newark); J. Ellis (Southampton); J. Oswald (London); T. Baugh (Birmingham); J. Bullock (Smethwick); W. Vickers (Birmingham); J. B. Tattersall (Birmingham); F. Vickers (Birmingham); Alex. Lawrie (Hurlford, N.B.); R. W. Kenyon (Accrington); H. P. Mason (Oldham); Samuel Dawes (Coalbrookdale); Thomas Macfarlane (Horsehay, Salop); Sydney A. Gimson (Leicester); R. Mason (Birmingham); Thomas W. Markland (Bolton); W. C. Prestwick (Dronfield); William Roxburgh (Kilmarnock); F. W. Finch (Gloucester); M. H. Curnow (Penryn, Cornwall); D. Dalrymple (West Bromwich); Geo. M. Riches (Beccles); W. E. Noon (Halifax); H. Grandidge (Bury, Lancashire); Harry Winterton (Birmingham); William Smalley (Castleton, Manchester); W. Mayer (Dumbarton); A. Bowman (Burnham-on-Crouch); P. Munnoch (Middlesbrough) Jas. Smith (South Shields); Jas. Chadwick (Bolton, Lancashire); Walter Evans (Falkirk, N.B.); James Read (Newcastle-on-Tyne); William Mathews (Wallsend); O. F. Hudson (Birmingham); Richard Carrick (Shipley, Yorkshire); G. M. Mather (Ashford, Kent); Richard F. Walker (Uttoxeter, Staffordshire); W. Broughton (Redcar); W. Sykes (Sheffield); Geo. W. Slooper (West Hartlepool); J. Shaw (Dudley); T. H. Hawley (Manchester); J. T. Magson (Littleborough, Lancashire); H. Walker (Newcastle); E. C. Burnup (Newcastle); W. W. Cooke (Newcastle-on-Tyne); John McHard (Newcastle-on-Tyne); Andrew Hunter (West Hartlepool); J. Flack (Southampton); W. S. Kenyon (Accrington); C. H. Bray (Wallis Brothers, Limited, Sunderland); H. Stonewall Jackson (Middlesbrough); H. Pilkington (Chesterfield); Everard Walker (Rotherham); J. Napier (Wallsend-on-Tyne); J. W. Pollard (Chesterfield); A. B. Howing; W. Ridley Makepeace (John Abbot & Company).

In opening the Convention the PRESIDENT said:—Gentlemen, I am pleased to welcome you again to our annual Convention, and I venture to hope that the time is not far distant when we shall not only be able to meet for an annual Convention but be able to have more

than one meeting in the year. I think we all value these meetings, not only for the papers and discussions and visits to works, which in themselves are very valuable, but for the opportunity they afford us of meeting together and being able to talk in a fraternal way to one another, and making mutual acquaintances amongst the founders present. I therefore hope that we shall be able to arrange for at least one other meeting in the year. If not quite of the character of the annual one, still we could have a meeting on somewhat different lines which would be much appreciated, I feel sure, as another opportunity of meeting one another. (Hear, hear.) I am sure you will all appreciate the programme which, with the valuable assistance of the Local Committee, the Secretary has managed to arrange, and I have no doubt that the Convention will be equally successful with those which we have hitherto held. (Applause.). I will now ask the Secretary to read the minutes of the annual meeting held at Sheffield last year.

The HON. SECRETARY (Mr. J. E. H. Allbut), read the minutes of the Convention held at Sheffield last year.

MR. SYDNEY R. GIMSON proposed, and MR. R. MASON (Birmingham) seconded, their adoption, which was agreed to unanimously.

The following report of the Council and financial statement had been printed and circulated among the members:—

Annual Report of the Council for the year 1907.

The Council have pleasure in presenting to the members the following report of the progress and work of the Association during the past year.

During the year His Majesty the King has conferred the honour of knight-

MEMBERS OF THE BRITISH FOUNDRYMEN'S ASSOCIATION AT THE OPENING SESSION AT ARMSTRONG COLLEGE.

Left to right, beginning at bottom row:—
1st Row: J. Ellis, E. Scott, W. Dalrymple, W. H. Sherburn, A. Caddick and D. G. Cochrane.
2nd Row: J. Oswald, T. Baugh, J. Bullock, W. Vickers, J. B. Tattersall, F. Vickers, A. Lurie, S. Dawes, H. P. Mason, T. Macfarlane, Representative of "THE FOUNDRY TRADE JOURNAL."
3rd Row: V. L. Cannell, F. J. Cook (President), H. Grandige, W. E. Noon, G. M. Riches, D. Dalrymple, M. H. Curnow, F. W. Finch, W. Roxburgh, W. C. Prestwick, T. W. Markland.
4th Row: W. Smalley, W. Mayer, A. Bowman, P. Munnoch, J. Smith, J. Chadwick, W. Evans, J. Reid, W. Mathews.
5th Row: R. W. Kenyon, D. W. Slooper, W. Sykes, W. Broughton, R. F. Walker, G. M. Mather, R. Carrick, R. Buchanan, (——).
6th Row: O. F. Hudson, etc., etc., etc. Standing on the right from bottom: P. Longmuir (Vice-President), S. F Gimson, (——), Herbert Pilkington, C. Jones (Vice-President), R. Mason, J. E. H. Allbut (Hon. Sec.)

hood on our life honorary member, Mr. R. A. Hadfield (Bessemer medallist), M.Inst.C.E., M.Inst.Mech.E. A medal has been awarded by the Royal Society of Arts to our late President, Mr. R. Buchanan, F.R.S.A.

Mr. F. J. Cook (future President) has been awarded a diploma by the Birmingham Association of Mechanical Engineers for the best paper of the session.

Our Vice-President, Mr. Percy Longmuir (Carnegie medallist), has gained the degree of "Bachelor of Metallurgy" at the Sheffield University.

The total number on the roll of the Association at the present time is 320, consisting of five life members, 29 hon. members, and 286 members; which, as compared with five life, 15 hon., and 230 members the previous year, shows a net gain of 70.

During the past year one member has resigned, and 14 hon. and 57 members have been elected.

The accounts for the year ending December 31, 1907, are now submitted, having been duly certified by the auditors appointed at the last annual meeting.*

The total revenue for the year was £129 4s. 6½d., while the expenditure was £96 9s. 1d., leaving a balance of revenue over expenditure of £32 15s. 5½d.

During the year the Council have held seven meetings, and members have attended from Accrington, Birmingham, Cardiff, Chesterfield, Gloucester, Horsehay, London, Leicester, Rugby, Sheffield, Southampton, and Warrington, and matters of considerable importance to the Association have been thoroughly discussed.

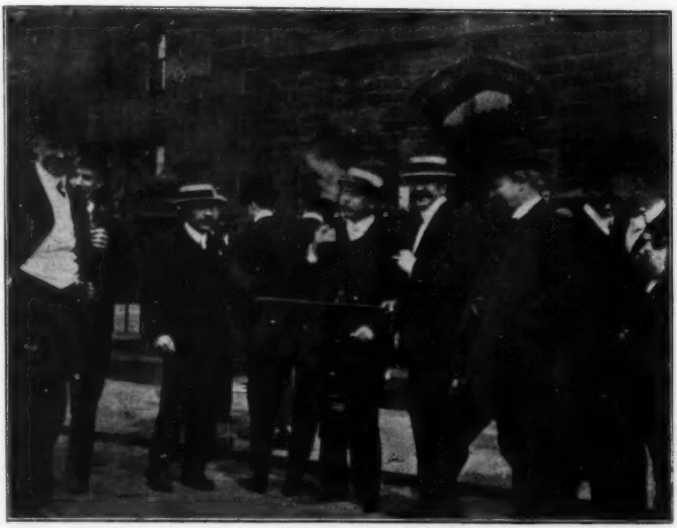
The rules have been revised, and are now in the hands of the Registrar for registration.

The method of electing members for the Council has been considered, and it will be proposed at the Convention that each member be elected for a period of two years, half the Council, *i.e.*, six, to retire each year, these to be eligible for re-election. Members to be nominated at least a month before the Convention. Election to be by ballot.

The Council have in hand a short concise history of the origin, objects, and progress of the Association.

The Council have pleasure in reporting that the Branches have done most excellent work during the past session.

The following papers have been given :—



A GROUP ABOUT TO ENTER THE COLLEGE.

* For this balance sheet see FOUNDRY TRADE JOURNAL, May.

"Crystallisation in Cast-iron," by Professor Turner, Birmingham University; "Foundry Ideals," and "Steel Castings," by Professor McWilliam, Sheffield University; "Founding, Ancient and Modern," and "Cupola Practice," by R. Buchanan, F.R.S.A., Birmingham; "Theory and Practice in the Foundry," "Moulding Sands," and "Cast-Iron," by P. Longmuir (Carnegie medallist, B.Met.), Sheffield; "Softening and Annealing Castings," by E. L. Rhead, Manchester University; "Securing the Co-operation of the Workmen in the Improvement of Workshop Methods," by R. W. Kenyon, Accrington"; "Influence of Carbon on Iron," by A. H. Hiorns, Birmingham; "Foundry Castings," by W. Stocker, Birmingham; "Notes on Contraction," by Alex. Fraser, Birmingham; "Tensile Testing of Cast-iron," by F. J. Cook, Birmingham; "The Selection and Testing of Foundry Irons," by F. M. Thomas, Birmingham; "The Testing of Alloys," by W. B. Parker, Rugby.

Five visits to works have been arranged during the session by the Birmingham Branch, which have been very interesting.

The Council desire to thank the proprietors for their kindness in allowing these visits, also the gentlemen who have kindly given papers during the session.

At the request of the members, the annual Convention was held in Sheffield on August 6 and 7. Five papers were read and discussed, and visits were arranged to various works and places of interest in the district. The attendance at the meeting was 86 members and 20 visitors.

Adoption of the Report.

The PRESIDENT: Gentlemen, the next business is to receive the report of the Council. I do not think it is necessary for that to be read. Everyone, I believe, has had a copy of it. (Hear, hear.) In formally proposing that it be received and adopted, I need only make one or two comments upon it. We have been successful in increasing the number of members of this Association, particularly of the honorary members, and our finances are in a satisfactory condition, as you will see from the accounts presented. Further than that, as I mentioned at the Sheffield meeting, we have carefully considered the question of the election of members of the Council. You will see that a proposition is to be made at this meeting which, I believe, will meet the case. (Hear, hear.) I think you will agree that the time has arrived when it is highly desirable that nominations should be received from the general body of the members. (Hear, hear.) I may point out that while this was a new Association the Council made the nominations, knowing who were the best men to enlist to support them in

BOARDING THE STEAMER AT NEWCASTLE QUAY FOR WALLSEND.

running the business of the Association. I believe we have been successful so far in getting the best members to serve, but it was obvious that a time must come when the general body of the members should have a voice in the selection. That time, I think, has now arrived, and I trust that you will approve of the action which has been taken in the matter, and adopt the scheme which is included in the report of the Council. (Hear, hear.) I have much pleasure in moving that the report and balance-sheet be adopted. (Applause.)

MR. F. J. COOK (Vice-President): I have great pleasure in seconding that motion. I think the work so far has gone on very well, and that the mode of

A GROUP OF MEMBERS.

J. McFee, D. Dalrymple, R. Mason, M. H. Curnow, F. W. Finch, S. Dawe, T. McFarlane.

electing the Council was the best that could be devised for the time. But now we are getting more into working order, it is advisable that we should have some system such as has been suggested. (Hear, hear.)

The adoption of the report and balance-sheet was then carried unanimously.

Election of Officers.

The PRESIDENT: The next business is the election of officers. It is at once my duty and pleasure to propose that our Vice-President, Mr. F. J. Cook, be elected President of this Association. (Applause.) You all know what excellent work Mr. Cook has done, not only in reading papers at our Conventions, and at the Branch meetings at Sheffield and at Birmingham, but also in many other ways—(hear, hear)—and I think you will all agree that as a thoroughly practical foundryman he is particularly suitable to be President of this Association. (Applause.) I have much pleasure in moving that he be elected President, and I don't think anyone else is likely to be proposed. (Hear, hear.)

MR. LONGMUIR: I have very great pleasure in seconding the nomination of Mr. Cook as President. All that Mr. Pilkington has said I can most heartily endorse. I should like to add that Mr. Cook, in addition to being a practical man, is also a scientific foundryman. We know well that in electing him to this post we are electing a President who will be a credit to this Association, and who will do his duty faithfully and well. (Applause.)

The motion was carried with acclamation.

MR. COOK: Gentlemen, I thank you for the confidence you have placed in me. I can only assure you that I shall do the very best I can to carry on the work of this Association to your satisfaction. (Applause.) My next duty is to propose, as senior Vice-President of this Association, Mr. Percy Longmuir. Mr. Longmuir is a metallurgist of the first water, and one who is known all over the world. (Hear, hear.) That alone would be sufficient to justify you in electing him as your Vice-President. But you have to add to that worth the ability he has shown as a member of this Association, and the work he has done for it. That again would be alone sufficient to warrant us in electing him. (Applause.)

MR. FINCH: I can assure you it is a great pleasure to me to second the proposition that our worthy friend, Mr. Longmuir, be Vice-President, knowing as I do the interest he took in the Association Committee before it was formed, for he was one of the first to initiate it. He advocated it in the JOURNAL, and happily it was taken up by others. It is therefore a great pleasure to me to second this nomination. (Applause.)

The proposition was carried unanimously.

MR. R. BUCHANAN in proposing as junior Vice-President, Mr. Charles Jones, of Cardiff, said: "He also occupies the position of President of the Cardiff Branch, and when the time comes he will, no doubt, occupy worthily the Presidential chair of this Association."

MR. J. ELLIS seconded, and Mr. Jones was unanimously elected.

MR. BUCHANAN: I have now much pleasure in proposing for the position of Honorary Treasurer our old and es-

teemed friend Mr. Finch. (Applause.) Mr. Morehead, unfortunately, is not able to continue holding the position for this year, and it occurred to us that no worthier occupant of that position could be found than Mr. Finch.

MR. GIMSON seconded the nomination which was carried unanimously.

MR. FINCH, who was received with applause, said: Mr. President, and Gentlemen, I heartily thank you for electing me to this position, and I will endeavour to do in the position of Treasurer what I have done in the past as Secretary; work to the best of my ability for the best interests of this Association. (Applause.)

MR. R. MASON, in proposing the re-election of Mr. Allbut as Secretary, said: "We of the Council know how well he has done his work. The ordinary members, of course, do not know this so well as we do. It is very difficult for anyone to follow in office a gentleman like Mr. Finch, and to be just the same as he has been, or to show any very striking results after the work he has done. But I can assure you that Mr. Allbut has done extraordinarily good work, and the Council are quite delighted at the way in which he has done it. When you consider that this Convention is held so far away from his home, and how he has had to attend meetings in Newcastle and travel home during the night in order to do the work of the Association—and over and above that has had to do the ordinary work of the secretaryship. you will realise the labour that has fallen upon Mr. Allbut. That labour has been done in a highly creditable manner, and we cannot do better than re-elect him. (Applause.)

MR. J. OSWALD seconded, and the proposition was carried unanimously.

MR. ALLBUT: Mr. President and Gentlemen, I thank you very much for electing me as Secretary again. I also heartily thank the Council for the way in which they have worked with me. There is very much to be done, and if we all continue to work together in the way we have done, the Association may look forward to still greater success. I am looking forward to a time not far distant when instead of 320 members we shall have 500. (Applause.)

The PRESIDENT: We have now to proceed to the election of Auditors. Up to the present time the Auditors have been resident in Birmingham, but we think it would be better now to change to another part of the country.

MR. R. W. KENYON then proposed Mr. Pilkington and Mr. Longmuir as Auditors.

MR. R. MASON seconded the motion, which was agreed to unanimously.

The PRESIDENT: The next question is that of the election of the Council. You have all heard the proposition with regard to the election of members of the Council in future, but though you have approved of it, it does not come into force until next year. In the present instance the election will be carried out as before. The nominations for the Council are:—Messrs. W. F. Bagnall (Sheffield), J. Ellis (Southampton), S. A. Gimson (Leicester), R. W. Kenyon (Accrington), T. Macfarlane (Horsehay, Salop), R. Mason (Birmingham), C. Morehead (Rugby), P. Munnoch (Middlesbrough), J. Oswald (London), W. H. Sherburn (Warrington), J. Smith (South Shields), and W. Vickers (Birmingham).

MR. R. CARRICK proposed that the gentlemen nominated be elected *en bloc* as the Council for the ensuing year. MR. H. P. MASON seconded the motion, and the gentlemen nominated were unanimously elected.

MR. WINTERTON in suitable terms then moved a hearty vote of thanks to the officers of the Association, from the President downwards, for their services during the past year.

MR. J. SMITH (South Shields): It gives me great pleasure to second this vote of thanks. I am sure the officers have done their work in the most splendid manner, and Mr. Pilkington has been an excellent man at our head as President of this Association. Although we sometimes differ a little upon points in the various activities of our Association, still we all believe that he has the best interests of the Association at heart.

The motion was carried with acclamation.

MR. PILKINGTON, in reply, said: Mr. President and Gentlemen, I thank you very much, indeed, for your kind expression of opinion, and Mr. Winterton and Mr. Smith for the words they have used with regard to our services. I assure you that it has been a great pleasure to me to conduct the work of the Association, and to look back this morning over my year of office. It is true that differences of opinion occasionally occur, but I am sure you all recognise that in all that I have done I have endeavoured to act in the best interests of the Association. (Hear, hear.) I believe the Council and the Vice-Presidents and the other officers of the Asso-

ciation have been actuated by but one feeling—the good of the Association, and we have received excellent co-operation from the Honorary Secretary. I believe we have succeeded, at least to some extent, in putting the thing on a more business-like footing, and I thank you for your expression of gratitude and for all your kindness towards me. I feel quite satisfied that we have done what we can, and I am quite sure the new officers and your new President will continue that work. It is well that officers should not be in office too long. It is for the good of the Association that they should change as they do, and I am sure the new officers of the Association will prove themselves as capable as those they have succeeded.

Presentation to Mr. Buchanan.

MR. PILKINGTON: I have now a very pleasant duty, indeed, to perform, and that is to make a little presentation to Mr. Buchanan, our first President. You all know how well he worked, and how strenuously he laboured for this Association, during his year of office, and he has continued this ever since. (Applause.) We all know how he travelled about, attended the Branch meetings, and used all the personal influence he had at his command to promote the interests of this Association. The Council thought that some tangible evidence of our appreciation and esteem should be given to Mr. Buchanan, and so they decided to present him, in your name, with this illuminated address, which says:—

"To Mr. Robert Buchanan, F.R.S.A.

"The members of the British Foundrymen's Association desire to place on record their sincere appreciation of the very valuable services you have rendered to us as President during the first two years of the Society's history. As an Association, the very excellent standard you set us in connection with the conduct of affairs and educational methods will serve as a model for our future guidance. We have much pleasure in asking your acceptance of this address as a small token of respect and esteem, and earnestly hope that you may enjoy every happiness and prosperity in the future.

"Signed on behalf of the members,
"Herbert Pilkington, M.I.C.E.,
"President.
"F. J. Cook and Percy Longmuir
"(B. Met.), Vice-Presidents.
"J. E. Allbut, Hon. Secretary."

I do not know that I could improve on the language contained in that address. I can only trust that we shall always have Mr. Buchanan with us as long as he lives. (Applause.) I have great pleasure in presenting to you, Mr. Buchanan, this illuminated address as a token of our esteem and appreciation, and as some recognition of the hard work you have done for this Association.

MR. PILKINGTON then presented the address. It was artistically illuminated and mounted in a handsome gilt frame. The members heartily applauded Mr. Buchanan, who, however, had to defer his reply on account of the arrival of the Deputy-Lord Mayor, to give the civic welcome to the Association. His reply, when the opportunity came to deliver it, was as follows:—

MR. BUCHANAN: I can assure you I appreciate in the highest possible manner the kindness of the Council and members of this Association in presenting to me this illuminated address. I do not know that in any form of compliment which you could give me you could have hit upon anything better than this address, which I can leave to my children to be constantly with them when I am gone. As regards this Association, it is a deep source of pride and satisfaction to myself that I had anything to do with instituting it, and carrying it along to its present position. Seeing that it is only five years since ten or twelve of us met in Birmingham and decided to form this Association, and that now we have 320 members, I think you will agree we have made excellent progress. (Applause.) We set out with a high ideal before us. We thought that however advanced our country was on the practical side of ironfounding, it was not doing all that it ought to be doing to balance that practical skill by knowledge of a scientific type. So we fought and worked strenuously in the hope that we should be able to keep this country in front so that it should not be left behind by any other country whatever, either on the practical or scientific side of ironfounding. We have been supported both by distinguished metallurgists, such as we have here this morning, and by practical foundrymen, and it gives us the greatest possible encouragement to find that not only among scientific men, but also amongst the practical foundrymen, this Association is recognised as worthy of support. We feel that we are doing a good and patriotic work. (Applause.) I desire to make it known to foundrymen who have joined us that we

do not intend to be too severely scientific, but that we welcome among us any man who, even if he does not read papers, can talk of practical work, and give us his ideas. There is no foundryman who joins this body but can bring an opinion of some kind or other, and so contribute to the interest and usefulness of this Association, and to the well-being of the industry. No single individual knows the whole round of foundry work; we are all specialists in some particular line, and I am particularly anxious that a man who does not write articles and who does not write papers, but who can tell us things that we want to know should feel that any contribution he may make to our discussion will be heartily welcomed. (Hear, hear.) It is a great feature of this Association that our meetings are perfectly open. They are open to any man who knows his business, and a man who has any practical difficulty, and who has found how to deal with it, can come and tell us what he knows about it. I particularly ask those who are here and those who I hope will read my remarks to note that we are anxious that all grades of foundrymen shall come amongst us. If they read papers we shall be delighted, and if they do not read papers and will just tell us some of the lessons of their experience we shall also be delighted. We are democratic. No man is barred. We are all willing to teach and to be taught, and that is my ideal of an Association such as this. In no branch of work in which I have been engaged have I found greater delight, and greater reward. (Loud applause.)

Newcastle's Civic Welcome.

The Deputy-Lord Mayor of Newcastle (Councillor Appleby), wearing his robes and chain of office, and accompanied by the Sheriff (Mr. W. Lee), in his official uniform, arrived just as the presentation was being made to Mr. Buchanan. They were attended by the Sword-Bearer and Mace - Bearer. Having asked Mr. Buchanan to defer his reply, the PRESIDENT conducted the Deputy-Lord Mayor and Sheriff to a seat on his right, and said :—

Gentlemen, we are honoured this morning with a visit from the Deputy-Lord Mayor of Newcastle. (Applause.) I am sure we are all delighted to receive this condescension on his part, because we all know what a busy life any Lord Mayor has during his year of office. The Deputy-Lord Mayor will now say a few words to us.

The DEPUTY-LORD MAYOR : Mr. President and Gentlemen, in the first place I have to express the Lord Mayor's regret that he is unable to be with you in person to-day, to extend to your Association a hearty welcome to our city. His Lordship is in Sweden, together with the Lord Provosts of certain Scottish cities, making a tour of inspection of some of the industrial undertakings of that country (including some of particular interest to your Association). It is, however, my privilege and pleasure to be the bearer of this civic greeting, to express every good wish for the success of your fifth annual meeting. I do not think you could very well have chosen a more appropriate centre for your annual meeting and deliberations than Newcastle, while the building in which you are assembled to-day, "The Armstrong College," suggests by its name a close and intimate and very practical association with many matters which must be dear to you all. (Applause.) Coming to the subject-matter of your Conference, the history of iron covers the historic period itself, and it may be said to be interwoven with the histories of many countries besides our own. No nation has been more distinguished for its application of the metals concerned, and none, I venture to say, has contributed more to the development of the scientific side of the question than the United Kingdom. We have, however, keenly enthusiastic competitors to face at the present day, and in face of this the existence of such Associations as yours becomes every day more and still more important to the nation as a whole. This busy centre of commerce and manufacture has been much indebted in the past to the art of founding, and in the course of your visits to our local works (some of which have achieved world-wide renown for their productions) you will see that Tyneside has not been slow in taking advantage of the scientific research of the founder. Particularly has this been the case since the introduction of iron into shipbuilding; and probably in no part of the world will better examples be found for your consideration than on Tyneside. It is an encouraging sign of the times that it is being recognised more and more, in connection with the various manufactures of the country that it is of the first importance that the scientific should be developed simultaneously with the practical knowledge of the subject; and as far as I can gather this appears to be one of the principal objects of your Association. If the opportunities which membership of your

Association offers to those interested in the various branches of founding are made use of, the result will be a higher conception of the art and a gain to the community; nothing being so well calculated to enhance the industrial prospects of the country as this all-round blending of science with practical effort. (Hear, hear.) In the name of the Lord Mayor, I must congratulate your Association upon the honours which have been conferred upon several of your members during the past year, and which I take to be indicative of further recognition to come of the value of your organisation. Mr. President and Gentlemen, I trust you will find on the coaly banks of the Tyne, and on the river itself, much to interest you, and to provide food for healthy reflection; and that, although this is the first, it will by no means be the last occasion on which you will honour Newcastle by making it your meeting place. I again express my regret that his Lordship is not present to add to this welcome the charm of his own personality.

The SHERIFF: Mr. President and Gentlemen, it is an exceedingly pleasant duty, indeed, for me to be here this morning in my official capacity, though I am here only to support the Deputy-Lord Mayor, to whom really falls the duty of giving the city's welcome. As one who is interested in your industry, I, however, have great pleasure in endorsing his words of welcome. As an old Novocastrian, I am delighted to know that you have chosen our city for your meeting, for we Novocastrians are proud of our city. We are proud of our river, and we are also proud of our great works, such as Palmers, where they deal at first hand with the iron ore that comes into this country; works where the iron goes in at one end in the ore, and comes out at the other in the shape of a magnificent sea-going vessel. Such vessels as the "Mauretania," or one of our ironclads cannot be turned out without the aid of the great skill of our ironfounders and of others engaged in the manipulation of iron. Newcastle is indeed closely associated with the industry you represent, and I beg to join the Deputy-Lord Mayor in giving you a hearty welcome to our city. (Applause.)

The PRESIDENT: Mr. Deputy-Lord Mayor, and Mr. Sheriff, we are all deeply indebted to you for coming here to give us a welcome, and for the grace you have lent to our proceedings. We are here to learn as much as possible from those whom we visit and from each other. Our Association is a thoroughly representative one. We have here foundrymen from the whole of the United Kingdom, from Cornwall to the North of Scotland. We are here both to learn all we can and to impart any knowledge we can, and we trust that our meetings will be such as will not be unworthy of the place in which we are met, and will be helpful both to it and to ourselves. We are very grateful, indeed, to you for your presence, and for the kind sentiments you have expressed.

The DEPUTY-LORD MAYOR: Mr. President and Gentlemen, I thank you for your vote of thanks and for so heartily receiving us, and I hope that your further proceedings will be both pleasant and profitable. We are glad to see you here, and I hope that the more we know each other the greater will be our mutual esteem, and that the ring of our friendship will never be broken. (Applause.)

The Deputy-Lord Mayor and Sheriff then retired.

MR. COOK, as President, next delivered his inaugural address, which was as follows:—

The New President's Address.

Gentlemen,—Having done me the honour of electing me your President for the ensuing year, I take this opportunity of assuring you that my constant endeavours will be to further the interests of this Association, and the welfare of its members. I feel that the position is a very responsible one, and hope, therefore, for the assistance of every individual member, not only in helping to increase the membership, but in extending the usefulness of the Association by inaugurating and fostering local Branches. The position is also one that I greatly value, since no greater honour can be conferred on any man than that of being chosen by his colleagues as the representative head of a national association representing the profession to which he belongs.

The selection of Newcastle for this year's Convention was, I think, most appropriate, as no more fitting place could be found in Great Britain. Newcastle is, and for many years has been, associated with some of the best examples and exponents of our craft. For more than sixty years that famous bridge (the greatest example of wrought and cast iron bridge design), with its fine truebow string arch, has proudly raised its head, and its 5,000 tons of cast iron is still a monument of which all foundrymen may well be proud. Here also is the birth-

place of many great engineering triumphs in which cast iron has played an important part. Note, for example, the great hydraulic work of the well-known Elswick firm; marine engineering in every phase—especially in connection with the country's first line of defence—and lastly, that latest and best example of naval architecture, which holds the records for size, palatial arrangements, and speed against all comers; I mean the "Mauretania," which has won back for us the premier position in express locomotion on the seas. In thinking of these achievements we must not forget the master minds of the workers, and whilst we acknowledge the ability of that vast army who have striven in every direction to bring about the great successes of which this city is so justly proud, we cannot but admire the ingenuity and perseverance of such men as Stephenson, and the generosity of the late Lord Armstrong, who not only brought fame to the district in connection with engineering, but also left behind him such a glorious example of philanthropy. To come to our own time, we have the Hon. Chas. A. Parsons, who has done so much to make a commercial success of the turbine. These, and many others, of whom time forbids my mentioning, form an array of which not only Newcastle, but England, are proud.

We are now entering on the third period of our Society's history, and at such a time it is opportune to make a short survey of those achievements which mark the progress already made, and to concentrate our aims towards further attaining the objects we have in view. When the Association was inaugurated, a little over four years ago, there were many, including myself, who were afraid that one of the great hindrances to our work would be the reticence of the members in connection with their own experience in the trade. It is not too much to say that previous to that time each foundryman in Britain had practically lived in a little world of his own, into which no one else was allowed to enter. But however real we believed that state to be, we all know how completely it has been broken down, and the outstanding feature of the first Presidency is what I may call, for want of a better expression, the Freemasonry spirit which was brought about, and which is still a predominant feature with us. Long may it continue! The period through which we have just passed may be truly designated after the famous play, "Our House in Order." The phenomenal growth of such a Society as ours, the members of which are spread all over the country, and who previous to a few years ago were practically unknown to each other, made it difficult to formulate and organise the working arrangement so imperatively necessary in a way that would ensure success. That this has been very largely accomplished is, I think, amply proved by the splendid Council which has been brought together, a body of men of whom any Society would be justly proud; and as time goes on I believe we shall look back appreciatively at the work in this direction of our Past-President.

Complete fellowship and good organisation thus being assured, it should give us time to further push on the car of progress, and enable us to extend our educational crusade by the formation of more local Branches, and by taking up our proper position in connection with the standardisation of the details of our trade. In connection with the former, one of the difficulties seems to be the arrangement of suitable programmes, owing to the shyness of many practical men, who, perhaps, have had little experience in addressing meetings, coming forward to read papers, but in this direction I see no reason why copies of a paper which is being read at one Branch should not be forwarded and used, say, on the same evening by other Branches; it would doubtless form good grounds for a discussion, and thus help to break down the shyness to which I have alluded. I would also suggest having open meetings to discuss debatable points, which have previously been decided upon and announced. In connection with the standardisation of details, there are many vital questions that require to be put on an up-to-date footing, such as complete specifications for physical tests, methods of grading and analysing iron, coke, etc., and these questions must either be faced by this Association or we must take such steps as will ensure our being represented on any National Committee dealing with foundry matters. Fortunately our immediate Past-President is a member of the Committee now dealing with the standardisation of tests for cast-iron pipes, but that is due, not so much to his position in this Association as to his commercial connection with the cast-iron pipe industry.

As a sign of educational advancement we gladly welcome the recent formation of the Institute of Metals, and earnestly hope their efforts will be successful. Al-

though it will add to the already large number of technical societies, the field in which they propose to work is largely virgin soil, and one in which combined efforts are urgently needed if British interests in the non-ferrous metals are to be maintained. The last fifteen years has seen many changes in connection with the grey iron-founding part of our trade. It is only a few years ago since the methods adopted in the foundry for iron-mixing were wholly rule of thumb, carried out by men who had learnt their trade in the hard school of practical experience. Then there sprung up, with mushroom rapidity, a school of young technical metallurgists who without foundry experience came forth with the cry that chemical analysis was the only way to ensure success. We have now come to the time when practical metallurgists of mature experience have found that, although chemical analysis is very important when considering problems in cast iron, it is only one of the agents to be taken into account, and such is the nature of the metal used that it is impossible to predict with certainty that positive physical results will follow a given analysis. This point, I think, was amply proved by Mr. Longmuir in his paper on "Theory and Practice," which he read at our last Convention. It can also be substantiated by anyone who has had to deal closely with foundry work.

Until very recent years scientific metallurgy had not entered into practical iron-founding. Consequently, there are many able foundrymen who feel the want of it, but who find a difficulty in getting just the kind of information that they can apply to their every-day work, and who are disappointed with the results when they try to solve many problems by chemical analysis alone. As I have previously pointed out, chemical analysis is only one of the agents to be employed, and I would urge on foundrymen to practice more than is done at present systematic physical testing, not as a substitute for, but in conjunction with, analysis. I therefore propose to briefly point out a series of tests that can be made daily in a foundry, without the expenditure of much time or money, to prove the physical qualities of the iron used. In doing so I feel that I am deviating somewhat from the orthodox broad lines of a presidential address, and narrowing it down to that of a paper. My only excuse is the benefits that will be derived by those who follow such a practice.

In the first place, when considering physical tests of cast iron, it should be remembered that the results obtained are only representative of the metal when cast in the same way as the specimen under observation, and do not necessarily represent the strength of other forms of castings made of the same metal, also that iron made into castings of various thicknesses, and, therefore, having varying rates of cooling, have different physical properties. Proof of this is readily seen in Fig. 1, a wedge shaped casting measuring 4 in. by ¼ in. at one end, 6 in. square at the other by 2 ft. long. This was cast with iron rather low in silicon and total carbon, and when broken through showed the fracture to range from white iron at the thick end to very open-grained spongy iron at

FIG. 1.

the other, with varying degrees of hardness throughout its length. The relative hardness is indicated by the numbers 40, 56 and 70, which represent the number of revolutions required to drill a hole to the same depth at the points shown. The iron specially suited for castings of about 1¼ in. to 2 in. thick, as a tensile test bar cast 1½ in. diameter and machined to 0.798 degrees diameter gave a breaking strain of over 15 tons per square inch, and a transverse test of over 3,000 lbs. on a bar cast 1¼ in. square, machined to 1 in. square, supported on centres 12 in. apart. Yet it will be seen that the metal would not be suitable for either very thin or very thick castings. It is therefore im-

perative, in order to obtain the greatest amount of practical information, that the test bars should, as far as possible, all be made the same, and the results logged with full information of the commercial castings made from the same iron.

One of the chief tests to a foundryman is that of shrinkage. There are several forms of apparatus for making the bars with, but that designed by Keep (Fig. 2) forms a very handy and cheap method. By this method a set of bars can be made by a boy in a few minutes. It consists—

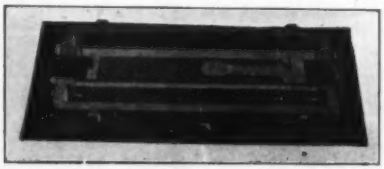


FIG. 2.

as probably many of you are aware—of a means of casting two half-inch square bars between the ends of a metal yoke, 12 in. apart. When the bars are cold the shrinkage is measured (Fig. 3) by a graduated taper scale, inserted between the end of the bar and face of the yoke. Although, owing to the chilling action of the yoke, and probably to the quicker rate of cooling, the shrinkage given will not coincide with that of the castings being made, it is surprising how well the work can be regulated after having ascertained the

FIG. 3.

contraction on the test bars which coincided with the best results in the foundry.

The shrinkage obtained by this method for—	
Stove grate work is usually about ...	.12
Medium sized ordinary work	.14
Maximum transverse test	.16
,, tensile test	.18
Grey mottled foundry iron	.20

It is sometimes claimed that this process will provide an estimate of the silicon content of the iron used, but this is not quite the case, since other elements also considerably affect the contraction. The variations in shrinkage, however, can be controlled by silicon by adding it when the contraction is too high and reducing the total content when the shrinkage is too low. The bars from this test can also be used to obtain a comparative indication of the chilling nature of the iron, as by splitting the end of the bars the chill caused by the yoke can be readily measured. Points to be carefully watched when making test bars by this process are that the ends of the yokes are kept clean and that the bars are of uniform thickness. Transverse strength is another useful test. There are three sizes of bars in general use for this test, *i.e.*, 2 in. by 1 in. on 3 ft. centres, 1 in. by 1 in. on 12 in. centres, and the ½ in. square bars obtained

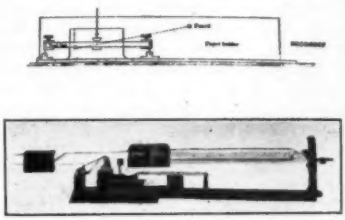
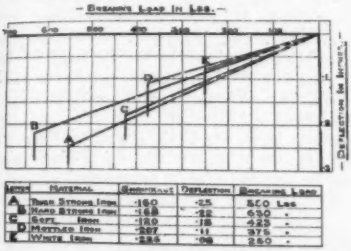


FIG. 4.

by the shrinkage test. The machines in general use in this country for ascertaining the transverse test of cast iron leave much to be desired as regards accurate working. In the cheaper ones the leverage can be effected by the operator, since it is necessary to move the poise along the beam by hand. He has, further, to watch the load on the beam, the deflection on the scale, and keep the beam in equilibrium, and immediately the bar breaks the only record that remains is in the operator's brain. This, of course, cannot be checked, as the beam drops as far as possible, the poise runs along the beam, and the deflection scale travels to its full extent. This is a condition of affairs far from satisfactory. All mechanical tests should, as far as possible, be purely mechanical, and leave a permanent record by means of charts or diagrams. There are now machines on which the poise is traversed by mechanism, and which remains in position after the bar has broken, enabling the load to be checked, but even

they give no deflection diagram. The machine, however, designed by Keep (Fig. 4) for use with the ½-in. square bars is free from the objections mentioned, the load being mechanically applied, the poise remaining stationary after the bar has fractured, and the deflection diagram can also be obtained.



Letter	Material	Specific Load	Deflection	Breaking Load
A	Thick Strong Iron	·160	·25	520 Lbs.
B	Hard Strong Iron	·168	·22	630 "
C	Soft Iron	·120	·18	425 "
D	Mottled Iron	·207	·11	375 "
E	White Iron	·225	·09	260 "

FIG. 5.

When starting a system of tests for foundry comparisons, it is best to adopt one of the three sizes of bars mentioned, and always work to it, otherwise the comparison is not a true one. It is generally known that the relative transverse strengths of cast iron bars do not follow the formula applied for strength of beams, owing to the skin area and rate of cooling

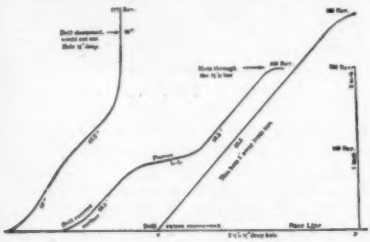


FIG. 6.

having to be taken into consideration; but for forming a rough idea as to the strength of the various bars mentioned when the result of one is known, Professor Turner gives it that a 1 in. by 1 in. bar, tested on 12 in. centres, has a breaking load equal to three-quarters that obtained on a 2 in. by 1 in. on 3 ft. centres, and after hundreds of tests I find that the breaking load on a ½ in. square bar by Keep's method is one-sixth of that obtained by the 1 in. square bar on 12 in. centres. A very important point to watch with transverse tests is the deflection, as by it one gets an idea of the flexibility of the metal—if one may use such an expression with cast iron—and Fig. 5 shows deflection diagrams taken on a Keep's machine for irons ranging from soft stove grate to grey mottled. From this it will be seen that to obtain a big deflection very strong irons have to be used, whereas some people believe that to obtain a big deflection soft iron should be used.

The hardness of the metal is of great importance where castings have to be machined, but more especially is this quality important where founders have to produce castings for wearing parts of engines, such as cylinders, liners, piston rings, valves, etc., whether for steam, gas,

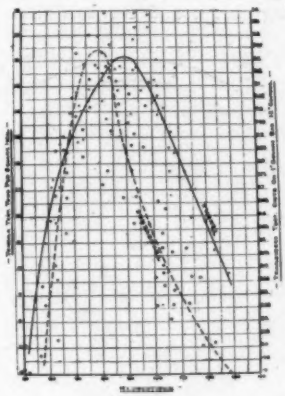


FIG. 7.

or oil engines. As it is the general hardness of the metal in question that is required, tests which give the surface hardness only are unsuitable, and the drill test is therefore applied. The only machine I know of that is specially made for this test is that of Keep's. The test is taken by drilling holes into the metal to be tested with a three-eighth straight fluted drill, running at 200 revolutions, an autographic record (Fig. 6), being taken at the same time to show whether the result has been influenced either by blow holes and spongy parts, or abnormally hard spots. The result is taken by measuring the angularity of the line on the diagram or the number of revolutions required to drill to a certain depth. An ordinary sensitive drilling machine, however, can be made quite easily to fulfil the requirements for this test by attaching a wheel to the feed spindle, from which a weight is suspended in such a manner as to give a direct down-

ward pull on the drill. To the drill spindle is fixed a pencil, which marks a diagram on squared paper attached to a drum revolving at a known rate—a convenient ratio being two revolutions of the drill to one square on the diagram paper. In fixing a standard for this test I prefer taking the number of revolutions to drill to a depth, as besides being more easily taken it conveys a better appreciation of the difference in hardness than taking the angle of the chart. By adopting squared paper for the diagram, both the depth and number of revolutions are readily checked without having to resort to measuring. It is generally known that the efficiency of a drill depends upon the point keeping sharp, and for hard iron it has

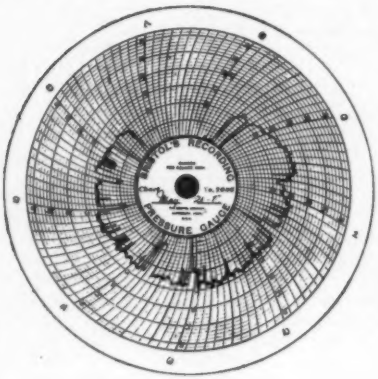


FIG. 8.

been found advisable to drill first a small hole, one-eighth of an inch in diameter, and then take the test with a ¼-in. drill. By this means the point of the drill is not damaged by possible hard spots. In making bars for this test it is most essential that they should all be of uniform size, otherwise the results will be conflicting.

This test, besides giving an indication of the hardness, is also a guide to the general strength of the iron, as hardness plays an important part in this respect. Fig. 7 shows diagrams of the hardness, transverse, and tensile test results of 70 consecutive tests with the same class of hard iron. For the transverse test, the bars were all cast 1¼ in. square, machined to 1 in. square, and supported on 12 in. centres. The tensile bars were cast 1½ in. diameter and turned to 0.796 in. in the centres, and from the results recorded it will be seen that hardness has been an important factor in the results obtained. It will also be observed that with hard irons the highest transverse results are obtained with iron a little softer than that which gives the best tensile tests.

One of the greatest influences in everyday working on the hardness of the iron being melted in a cupola is blast pressure. In many instances peculiar results have been obtained by neglecting to take note of the fluctuations of pressure which have arisen through various causes. Generally speaking, the question of blast pressure receives very little consideration from foundrymen, but where high-class work has to be produced very careful attention should be paid to this point. The neces-

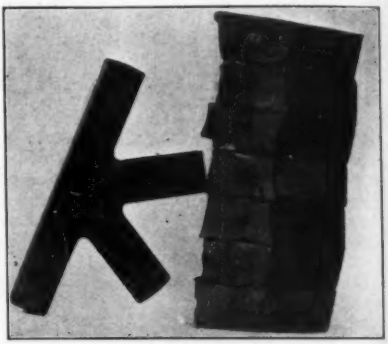


FIG. 9.

sity of a diagram in this case is even more marked than with some of the previous cases mentioned, for, with the usual measuring or water-gauges, it is impossible to check a day's working unless an attendant has stood by and constantly recorded the fluctuations. By adopting a recording gauge of the Bristol type, a complete record of the whole blow is obtained (Fig. 8).

My experience is that the hardness of cast iron is affected directly in accordance with the pressure of the blast, the amount of difference varying according to the type of cupola and the class of iron melted. With four cupolas, two of which are of the same diameters in the tuyere zone, but of different makes, I have noticed that with the same mixture of iron different blast pressures have to be used to obtain the same degree of hardness. The results obtained with one of the cupolas over a

long period when melting the same class of iron, show that with

9 oz.	blast	pressure	hardness	averages...		48
10 ,,	,,	,,	,,	,,	...	52
12 ,,	,,	,,	,,	,,	...	55
13 ,,	,,	,,	,,	,,	...	58
14 ,,	,,	,,	,,	,,	...	60
15 ,,	,,	,,	,,	,,	...	64
16 ,,	,,	,,	,,	,,	...	80
17 ,,	,,	,,	,,	,,	...	78

and the chemical changes that take place between the extremes show a decrease of total carbon of about 0.25 per cent., an increase of C.C. of about 1 per cent., and a very slight decrease of silicon—probably owing to this element being present in small proportion.

With castings which have to stand a high pressure, either of air, water or steam, difficulty is very often experienced with spongy places which leak under the water-test pressure. This generally happens where several walls of metal meet at or near one point, and notwithstanding that in many cases the design is not ideal, it is often found that the castings from the same pattern can be made for a time without giving trouble, and then suddenly similar castings fail to fulfil the desired test. Such has been my experience, and although I have not been able to prove satisfactorily the cause of this phenomena it can be shown at once when an iron will cause trouble in this direction.

The method adopted to detect this defect is to cast two test bars in the form of the letter "K" in one mould, the vertical leg being 6 in. long, and the two angular projections, each 3 in. long, by 1 in. square section. If the iron from which the test pieces are cast has a tendency to the trouble named, it will be clearly seen on breaking the test bars through the thick part. Fig. 9 shows a pattern of the test bar adopted, also samples of broken bars ranging from solid ones to those having open and spongy centres.

That this trouble cannot be detected by chemical analysis seems to be proved by the following analysis of two irons:—

Test No.	1,009. Per cent.	1,006. Per cent.
Analysis C.C....	0.720	0.736
G.C. .	2.280	2.295
Phos.	0.665	0.492
Sul.	0.056	0.064
Sil. ...	1.306	1.430
Mng.	0.432	0.432
Iron by difference, 94 ...	0.541	94.501
Shrinkage bar No. 1	0.203	0.209
Shrinkage bar No. 2	0.206	0.209
Transverse test ½ in. bar, 12in. centre No. 1	480 lbs.	470 lbs.
Do. do. No. 2	485 lbs.	465 lbs.
Deflector ½ in. bar. No. 1	0.150	0.156
Do. do. No. 2	0.10	0.156
Transverse test 1in. bar, 12in. centre No. 1	3.696 lbs.	2,856 lbs.
Do. do. No. 2	3,584 lbs.	2,940 lbs.
Tensile test bar No. 1	16 tons per sq. in.	11.1 tons per sq. in.
Do. do. No. 2	15.5 tons per sq. in.	8.3 tons per sq. in.
Condition of "K" bars ...	Perfectly solid.	Sunk and spongy.

Practically speaking, the composition of each is identical, and might be expected to give similar physical results, but actually the test results were widely different, and so prone was the one to the trouble mentioned, viz., liquid contraction, that it also affected the centre of the round bar cast 1½ diameter for the tensile test, causing a particularly low result for this class of iron. It will be noticed that the difference is not so marked with the small ½-in. square bars for the transverse test, owing probably to the quicker rate of cooling, but all the others are affected.

There are physical tests other than those already mentioned which are more or less important, such as tensile strength, but this test is of more concern to engineers owing to the bars requiring to be machined. The salient points in connection with tensile tests have been considered in a paper read before the local Branches, so there is no need to go over the ground again. Impact test is very rarely used, the deflection test being considered sufficient indication of the toughness of the metal. Metallography, although very interesting and instructive, is too big a subject to be dealt with here. There are, however, two very important tests which can be easily applied in the foundry, namely, the determination of the quantity and position of sulphur and phosphorus by mechanical means, but as this forms the subject of the next paper, I shall leave it to be more fully dealt with.

In conclusion, if the tests outlined are more generally applied to the separate pig-irons being used as well as to mixtures adopted, I feel sure we shall have made some progress in advancing the practical side of the great industry represented by our Association.

MR. LONGMUIR: I think that we all owe Mr. Cook, our President, the heartiest thanks for his admirable address. Presidents are privileged persons, and we are not at liberty to discuss their remarks. But without entering into any discussion I should like to note that Mr. Cook has

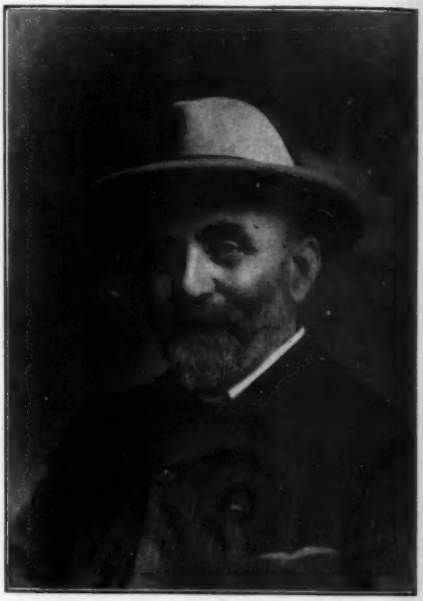
given us much to think over. He has shown us the value of common-sense science practically applied, and I think we ought to give him our hearty thanks for his splendid paper and its carefully thought-out matter. (Applause.)

MR. BUCHANAN: I have been asked to second the vote of thanks to the President for his most interesting address. As I am one of the upholders of the chemical test, it, of course, gives me a bit of a knock to have these things said. But, after all, foundry work is an evolution, and I am not too old to learn that I have made mistakes in the past. In fact, I should be very much surprised to find that I had not. Mr. Cook gives us a problem to work out; he does not undertake to elucidate it completely; he asks us to assist him in doing so. If anyone can tell us why these two analyses so much alike should be followed by such different physical results we shall all be delighted to hear. If not at this session at some future one. (Laughter.) But Mr. Cook has given us a delightful address, and these differences in physical results in the face of exact chemical agreement point us to the fact that there are happening things of which we know practically nothing. This gives us a zest in studying the subject, a subject which we cannot exhaust this year, nor next year. We can only go on trying to learn something about it in the hope that as time goes on we shall gradually get nearer the truth. I have much pleasure in seconding the vote of thanks to our President.

MR. F. W. FINCH expressed his support of the motion, which was carried with acclamation.

The PRESIDENT: Mr. Longmuir, Mr. Buchanan, Mr. Finch, and Gentlemen, I am very much indebted to you for all the kind things you have said and for this vote of thanks. I do not require it, and if you have received any pleasure or any profit from my remarks I shall be amply repaid. I did not know that Mr. Buchanan would take it so hard. I am not one of those who do not believe at all in chemical analysis, but I wished to give you some of the results of actual work in the foundry, so that those who do not know anything about chemical analysis, and wish to start investigating by physical tests might have something which would be useful to them. I have now to call upon Mr. J. E. Stead to give us his lecture. Mr. Stead, you all know, is a gentleman of high standing in the metallurgical world, and I am sure that anything that he may say must be of great interest, especially as the subject, as I have said, is one which can be dealt with as a working matter and not only as one for the chemical laboratory.

Mr. Stead's paper was illustrated with a splendid series of lantern views. A concluding slide, showing by the crystallisation in the slide of chloride of ammonia phenomena analogous to those described by the lecturer as taking place during the cooling of iron, made an effective finish to the lecture.



MR. J. E. STEAD.

The paper was as follows:—

IRON, SULPHUR AND PHOSPHORUS.

When asked to take some part in this annual meeting of the British Foundrymen's Association, I hesitated to reply in the affirmative; finally, I promised to give a lantern lecture, which really meant that the lecturer should take only a subordinate position, and my audience would gain the main part from Nature's own handiwork in photographs and experiments. It is science in the workshop, in the foundry, to which I want to direct

your attention, hoping that what you see and the scraps of truth you may glean may be like seed cast into furtile soil which will bear fruit and result in adding knowledge to that we already possess.

My lecture is entitled "Sulphur and Phosphorus in Iron," but beyond showing some interesting experiments illustrating how you can by the most simple method make cast iron tell you what sulphur is relatively present, I shall treat mainly on iron and phosphorus, a subject I have devoted much time and made specially my own.

Sulphur and Iron.

In the text-books you will find it stated that when a brightly red-hot poker is brought into contact with sulphur the iron apparently melts and runs away in very fusible liquid drops. These drops are, however, not iron, but a chemical combination of the iron, sulphur, and

FIG. 1.

Iron Crystallites, 10.0 per cent.
Iron Sulphide, 90.0 per cent.

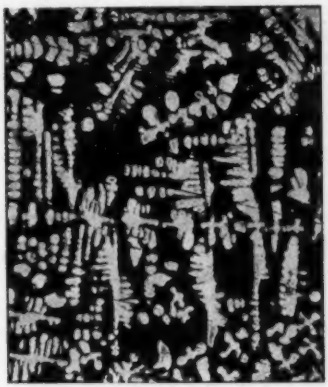


FIG. 2.

Iron Crystallites, 52.7 per cent.
Iron Sulphide, 47.3 per cent.

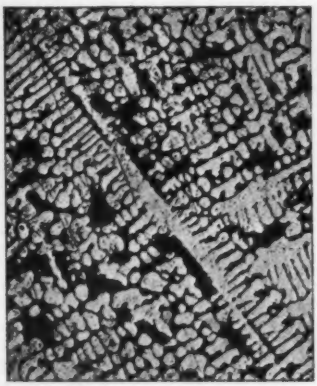


FIG. 3.

Iron Crystallites, 76.9 per cent.
Iron Sulphide, 23.1 per cent.

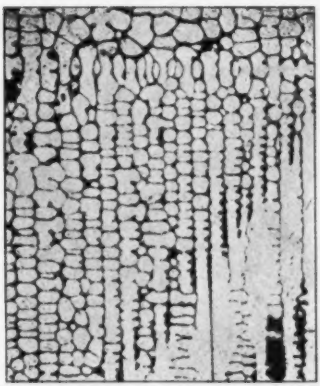


FIG. 4.

Iron Crystallites, 88.45 per cent.
Iron Sulphide, 11.55 per cent.

oxygen. If we take this substance and heat it in a crucible to whiteness and drop into it pieces of iron, the iron will be dissolved, and will mix with the original liquid, and as the temperature is raised more and more iron will dissolve and form as perfect a liquid mixture as salt in water. The two things are in liquid solution. On cooling down, the iron crystallises out in skeleton crystals in an almost pure state, but it does not sink to the bottom of the liquid in the way salt settles from brine in the salt pan, but grows in tree-like forms from the side of the cooling vessel into the solution, and the iron continues to grow in this way till the temperature falls to about 960 degrees C. Then the residue liquid, consisting of sulphide of iron with some iron, finally solidifies.

The photographs (Figs. 1—4) are of sections of solidified mixtures of sulphide and iron in varying proportion. In the first, where there is only about 20 per cent. of iron and 80 per cent. sulphide, the crystallite skeletons are clearly seen surrounded with the dark-coloured sulphide. The other photographs, representing larger proportions of iron, show greater and greater areas of white, corresponding with the larger amount of iron in the mixture. Experiment, therefore, shows that sulphide of iron and iron dissolve in all proportions and that the iron crystallises out in advance of the solidifying point of the sulphide matrix.

The sulphur in pig-iron, varying between bare traces up to 1 per cent., although in solution when the pig-iron is molten, is not, however, usually found in the cold pig as sulphide of iron, but as another sulphide called manganese sulphide, for manganese is usually present in commercial pig-irons in quantity sufficient to combine with all the sulphur. This sulphide has a higher solidifying point than the iron sulphide, and when more than sufficient manganese is present to combine with the sulphur, unites with the sulphur before any part of the metal itself solidifies, and it then actually separates, and being lighter than the metal, floats upwards and escapes to the surface or is entangled under the surface crust of the solidifying metal.

It is in this way that so much sulphur is caused to be eliminated from large masses of basic iron in the metal mixer and from the foundry ladle when time is allowed for the sulphide to rise to the surface. Little sulphide of manganese, however, does as a matter of fact float off unless the quantity of manganese exceeds half of 1 per cent., a fact known by foundrymen, for in order to effect desulphurisation ferro-manganese is added to the metal in the ladle so as to increase it sufficiently to expedite the separation of the sulphide. When the manganese is deficient practically none escapes, for the sulphide of manganese only forms when the metal becomes plastic, and is entangled between the branches of the crystallites of solid metal. When a surface of cast iron is moistened with a drop or two of sulphuric acid or hydrochloric acid, a distinct smell as of rotten eggs is experienced, and the intensity of the odour depends on the amount of sulphur in the metal; indeed, a marked difference can be detected between the effluvium from No. 3 and forge iron. The nose is at the best, however, a very uncertain and indelicate method of determining sulphur, and I now want to show you a very simple method devised by Mr. Bauman, by which the sulphur gas or sulphuretted hydrogen evolved by acid can be made to show in another way its relative proportional presence.

This consists of simply squegeeing pieces of gelatine silver bromide paper moistened with sulphuric acid on polished surfaces of cast iron, allowing them to remain one minute, and then removing them. The sulphur gas in approximate proportion to what is exposed on the metallic surface stains the paper brown by converting the silver on the paper into sulphide with a depth of tint increasing with the amount of the sulphur. The method is so simple I can readily make several trials before the meeting. The pigs selected are sections of Staffordshire pigs No. 1 to No. 6. I place on these the wetted silver paper, and you see at once that whilst there is little difference in the tints on the papers which have been pressed on Nos. 1, 2, and 3, there is an increasing darkening on Nos. 4, 5, and 6.

It is scarcely needful to point out to you the advantage to foundrymen of this simple method.

On the screen are shown photos of these and other auto-sulphur points which clearly indicate not only the relative amount of sulphur in the metals but how it is distributed.

Mr. Levey (Carnegie Research Scholar "Journal of Iron and Steel," 1908) and myself coincidentally discovered that carbide of iron and sulphide of iron mutually dissolve each other, forming a eutectic mixture, and I have proved that this eutectic can freely dissolve an excess of carbide of iron which crystallises out

of the solution in thick plates and is found in that form in the cold alloy surrounded by the eutectic. It would be an easy matter to go on during the time I have allotted, and for many more hours, in discussing sulphur and iron and give you the latest researches on that subject by Arnold, Le Chatelier and Ziegler, Trietschle and Tamman, and Levey, but I must pass on to consider the alloys of phosphorus and iron.

Phosphorus and Iron.

Iron when red hot readily chemically combines with phosphorus, with the production of greatly increased temperature.

The valuable research of one of the Carnegie students—Mr. Saklatwalla—communicated this spring to the Iron and

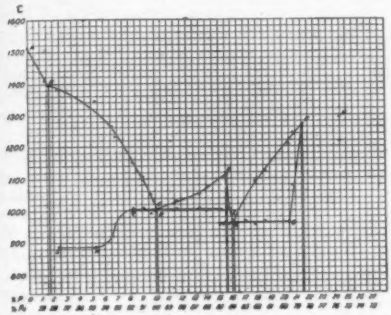


FIG. 5.—COOLING CURVE—TABLE OF IRON AND PHOSPHORUS ALLOYS.

The upper curve indicates that the effect of the first 1·7 per cent. phosphorus depresses the freezing point about 110° or 64° C. per unit of phosphorus.
The effect of 10·2 per cent. phosphorus is to lower the temperature of freezing by 510° or a mean of 50° C. per unit of phosphorus.

Steel Institute mainly confirms my own work, but as far as it went gives in addition most important pyrometrical observations. The summary of his research indicates as I had previously shown that the saturated solid solution of phosphorus and iron contains about 1.7 per cent. phosphorus, and that the first eutectic contains 10.2 per cent. phosphorus, also confirming my own result, but he found its melting point to be about 1,000 degrees C., as compared with 980 degrees—the temperature I had observed. He discovered that there is a second eutectic, melting at 960 degrees with 16.2 per cent. phosphorus, consisting of two definite compounds, Fe_3P and Fe_2B. He also found a third eutectic, probably with a higher phosphide, melting at about 1,218 degrees C.

The curve diagram (Fig. 5), reproduced from Mr. Saklatwalla's paper, shows graphically the effect on the solidifying point of a gradually increasing amount of phosphorus.

The term "solid solution" and "eutectic" require definition.

When mixtures which are quite liquid solidify without separation of any of the constituents, the cold mixture in each part of it is homogeneous, and it may be said to be a solidified liquid, and wanting a better term, it has been called a "solid solution."

Glass is a type of solid solution, for it is homogeneous and free from any pure separate crystals, although there are several constituents present.

The term "eutectic" refers to mixtures of two or more substances which mutually dissolve in each other and solidify at one given and fixed temperature, which is generally very considerably lower than the mean solidifying point of the constituents. For instance, salt and ice, on being mixed at near to the melting point of ice, mutually dissolve, and the liquid containing 23.5 per cent. salt and 76.5 per cent. water, the eutectic mixture cannot be frozen until a temperature of 22 degrees C. below the freezing point of water. The mean freezing point of the two substances when in eutectic proportions is 188 degrees. Water freezes at 0 degrees C., salt at 800 degrees C., and when frozen, the solid is found to contain free salt and ice in fine lamina. The mixture called a eutectic is analogous to a frozen "mother liquid," for it is the final portion to solidify when mixtures not in eutectic proportion pass from the liquid to the solid state.

Pure iron solidifies at about 1,505 degrees C. If phosphorus is added to liquid iron, the solidifying point of the mixture is lowered with each addition, and up to 1.7 per cent., the alloys are solid solutions. Polished and slightly etched surfaces of these solid solutions show only one even unbroken appearance; they contain phosphide of iron in solid solution in iron.

As soon as the phosphorus exceeds 1.7 per cent. the excess phosphide combines with a portion of the solid solution to form a eutectic mixture which separates and is imprisoned between the branches of the solid crystals of iron and phosphide.

In proportion, as the phosphorus is increased the eutectic increases, and the

fir-tree crystallites decrease until when the eutectic point is reached there are no longer any independent crystallites, and the melting point has fallen to about 1,000 degrees C.

The appearance of the eutectic under the microscope is that of the honeycomb of the bee, with this difference, that instead of the cells being hexagonal they are cylindrical.

The brilliant white parts represent the phosphide, the darker parts the crystallites of iron phosphorus solid solution. A crystallite differs from a perfectly-formed crystal; it is a crystal, but is not fully developed with its faces and angles. When we increase the phosphorus above 10.2 per cent. very perfect, true and well-formed crystals appear, and these consist of phosphide of iron. These crystals form at a higher temperature than about 1,000 degrees C., and when in cooling the excess phosphorus over the 10.2 per cent. is all separated in these crystals the residue liquid eutectic finally freezes at about 1,000 degrees C.

One of the most interesting discoveries made in my researches is the extraordinary effect that carbon has on the solid solutions of iron and phosphorus when they are heated together. These alloys are very coarsely crystalline, and fracture with large cleavage faces.

On causing carbon to enter such metals by cementation at a temperature a little above 1,100 degrees C., it passes in as solid carbon and throws out of solution as liquid a portion of the phosphide, and this forms a fusible mixture with carbide and iron as a complicated ternary eutectic, and actually runs or liquidates out of the metal.

The structure of the metal coincidently is entirely altered, but the part into which the carbon does not penetrate remains in the same coarsely crystalline condition as the original metal. The amount of phosphorus in the liquid which flows away depends on the temperature at which the cementation is effected, and has been found as high as 6 per cent.

In order to see exactly the progressive changes during carburisation, a piece of metal containing 1.2 per cent. phosphorus and 0.1 per cent. carbon was heated in pure sugar charcoal for one hour at about 1,200 degrees C. When still at that temperature it was removed and quenched in cold water. It was cut, polished, and etched, and a photo-micrograph prepared.

What it shows at the extreme point of penetration where the carbon is just entering the metal, is that it at once causes the metal to crystallise in very minute grains, whilst between the grains there is a substance which can only be the solidified liquid referred to rich in phosphorus.

The experiment indicates that phosphorus and carbon when in iron mutually repel each other under certain conditions. The carbon entering the metal by diffusion throws the phosphide out of solid solution, and this escapes outside of the metal. When iron, carbon, and phosphorus are melted together there is evidence in the micro-structures of the cold metal that phosphides and carbides there also repel each other, but the phosphide eutectic is imprisoned in the metal itself. An examination of any piece of grey pig-iron high in phosphorus will show this.

In the photo on the screen the graphite is clearly seen as existing in black curved plates, and at points as far off the carbon as possible is the phosphide eutectic, they do not like to be together, and fix their positions as far from each other as possible. In mottled iron the black specks contain much less phosphorus than the surrounding white iron Now there can be little doubt that the graphite commences to develop in these isolated spots, and radiate or develop from nuclei, and the phosphide eutectic is driven outward partly by the pressure of the separating graphite and partly by the repulsion which the liquid phosphide and carbide have in the solidifying and cooling metal.

In hard forge apparently the same thing occurs, as in mottled iron the metal at first becomes mottled, that is, the carbon as graphite develops from nuclei and the development proceeds in radial direction and eventually joins, producing an apparently homogeneous grey iron, but during the development the phosphide fusible eutectic is driven before the growing graphite areas, and finally is found imprisoned between the radial growths of grey metal.

When the phosphorettic iron is white the structure clearly shows that what first crystallises out are crystallites of iron with a little carbon, and probably a little phosphorus, but in the solid metal they appear as iron with above 0.90 per cent. carbon. These purer iron crystallites during their growth impoverish the liquid of iron and concentrate the carbon and phosphorus in the liquid, which then remains as a solution of carbide of iron in phosphide of iron eutectic. On cooling some of the carbide crystallises out of the eutectic in plates or sheets, and the

eutectic remains imprisoned between them and finally solidifies, breaking up into its three constituents of the honeycomb type and fine carbide plates.

A most valuable paper on the influence of phosphorus on the iron and carbon system has been written by Von F. Wüst. I here give the general conclusions of the author:—

1. The initial temperature of solidification of the saturated iron carbon alloys is lowered by the addition of phosphorus. On the average 1 per cent. phosphorus lowers the solidification temperature about 27 degrees C., until a content of 6.7 per cent. phosphorus is reached. Further additions of this body raise it.

2. There is a critical point at about 960 degrees C. in the cooling curve of pig-irons due to the solidification of the phosphorus eutectic which is quite independent of the amount of phosphorus present. The intensity of the arrest increases until the percentage of phosphorus amounts to 6.7 per cent. Further additions reduce the intensity of the arrest. With a content of about 15 per cent. phosphorus corresponding to the combination Fe_3C, the arrest point disappears.

3. The normal critical point of A 1, 2, 3, is not altered by phosphorus additions, its intensity diminishes to extinction when the phosphorus reaches 15 per cent.

4. The solubility of irons for carbon is decreased by the addition of phosphorus. This is indicated by a curve, which shows a break when the phosphorus reaches about 6 per cent.

5. In the presence of phosphorus, a very fusible ternary eutectic is produced in saturated alloys containing carbon, the constitution of which may, with tolerable accuracy, be accepted as—

	Per cent.
Phosphorus	6.7
Carbon	2.0
Iron	91.3

with a solidification point at about 950 degrees.

6. Many of the saturated iron phosphorus carbon alloys containing more than 6.7 per cent. phosphorus contain idiomorphic crystals of phosphide of iron which increase in quantity with increase of phosphorus up to 15 per cent. when nearly the whole mass consists of free phosphide.

Many of the general conclusions of Mr. Wüst practically agree with what have been previously published. The composition of the ternary eutectic of carbon phosphorus and iron determined by Mr. Wüst is very close to what I squeezed out of nearly solid Cleveland pig-iron in 1875, as is indicated by the following analyses:—

	Stead. Per cent.	Wüst. Per cent.
Combined carbon	1.75	2.00
Manganese	0.29	—
Silicon	0.79	—
Phosphorus	6.84	6.70

If we accept the view that one part silicon replaces about 0.20 per cent. carbon the 0.79 per cent. silicon in the expressed substance would replace $0.79 \times 0.2 = 0.158$ per cent. carbon; the silicon-free eutectic would therefore have the following corrected composition, viz.:—

	Stead. Per cent	Wüst. Per cent.
Carbon − 1.75% + 0.158 =	1.908	2.00
Silicon	Nil.	Nil.
Phosphorus	6.84	6.70

Such closely concordant results obtained by independent workers are highly satisfactory, so much so that it may be accepted that the phospho-carbide eutectic or the final substance to freeze in phosphorettic pig-irons is now fixed and beyond dispute.

Occasionally there are to be found little globules of metal in the blow holes of metal castings, and these consist mainly of the phosphorus-carbon-iron eutectic.

Mr. Munnoch kindly supplied me with several samples, together with the analyses of the globules and the casting from which they had exuded, an example of which is given below:—

	Casting. Per cent.	Phosphide drops. Per cent.
Combined carbon	0.62	2.20
Graphite carbon	2.74	Nil.
Manganese	0.51	0.63
Silicon	1.63	0.70
Sulphur	0.09	0.03
Phosphorus	0.88	5.68

The phosphide ternary eutectic is always quite white and very hard. The hard spots referred to which the tool jumps over and refuses to cut are almost certainly what were at one time honeycomb cavities which have been refilled with the eutectic.

On long heating of phosphorettic pig at 950 degrees C., Lencauchez found that the surface became covered with extruded globules of metal. The analyses of the casting and liquated metal were as follows:—

	Metal. Per cent.	Liquate. Per cent.
Combined carbon } Graphite carbon }	3.50	1.99
Manganese	—	—
Silicon	2.60	0.82
Sulphur	—	—
Phosphorus	1.90	5.45

The observation of Mr. Wüst that crystals of phosphide appear in phospho-carbon iron alloys when the phosphorus exceeds 7 per cent. was also noticed by me five years ago.

It must not be assumed that the ternary eutectic which has approximately 2 per cent. carbon and 6.8 per cent. phosphorus at its solidifying point has always that composition in the eutectic areas in the cold alloys, for there is reason to believe that a profound change takes place after it has solidified, in metals which contain much graphite.

The microscope helps us to that conclusion. If the structure of the cold eutectic areas of white and grey metals are examined side by side, they are found to be quite different.

That of white iron consists of a mass of phosphide of iron with meshes of pearlite, and in this are embedded plates of carbide of iron. It is probable that this eutectic corresponds closely with that, with 2 per cent. carbon and 6.8 per cent. phosphorus with a point of solidification of about 950 degrees C.

The eutectic in very grey metals is similar to the last, but is free from the carbide plates and contains very little carbon, probably not more than 0.30 per cent. The point of solidification of the eutectic is presumably the same in both metals, and at or near this point they have the same composition. When in grey iron the carbon begins to separate as graphite the surrounding metal is impoverished of carbon, and is then capable of receiving some of that in the eutectic, and as carbon is capable of rapid excursion or diffusion it leaves the eutectic and passes through the intervening space, travelling towards the graphite and reaching it falls out of solution and thickens the plates of graphite by adding carbon on each side. This continues when the eutectic is still in a plastic state, and for some time after it has become solid. The presence of high silicon accellerates the precipitation of the carbon as graphite and the absence of sulphur tends in the same direction. In pigs of rich grade, high in silicon, the structure leads one to believe that the passage of the carbon is more rapid from the eutectic to the first formed plates of graphite than it is in pigs lower in silicon; not because carbon diffuses more rapidly in siliceous iron than in iron with less silicon, but because what does diffuse is more rapidly precipitated, and the intervening passage being thus freed from carbon is in a condition to more readily receive the onrushing carbon from the eutectic.

If the silicon is very high, say, 5 per cent. or more, when the pigs are cold, the intervening spaces between the eutectic areas and the graphite are quite free from carbon and the eutectic contains not more than traces of that element. The passage in such cases is complete. When the silicon is about 2½ per cent. to 3 per cent. the passage or transfer of the carbon from eutectic to graphite is rarely complete. The tendency for the intervening iron to retain its carbon is greater than in the former case, and a portion of the carbon is found in the areas adjoining the eutectic more or less completely enveloping them in the condition of pearlite, whilst the areas close to the graphite are free from carbon.

In proportion, as the silicon decreases, the intervening spaces become more and more filled with pearlite carbon, and the ferrite or carbonless envelopes round the graphite become thinner and thinner till finally when the silicon is sufficiently reduced it disappears. Analysis confirms the fact, as is well known, that as the silicon is reduced the combined carbon steadily increases.

In some grey irons I have examined the eutectic areas have still contained some of the original carbide plates, but these were in irons which had been very slowly cooled, and in which relatively great distances intervened between the graphite plates and the eutectic areas—probably ten times as great as in pig-iron of the ordinary size cast in sand on the pig bed.

Researches have shown that in pig-irons (even though the phosphorus is only present to the extent of 0.04 per cent.) the carbon throws out of solution the phosphide, and this remains as eutectic. This eutectic must be in quantity corresponding to the amount of phosphorus in the pig iron, so that an examination of sections polished and etched should show whether the phosphorus is in great or small amount. The series of photos exhibited indicate that such is the case. The sections were first polished and then were strongly etched with 20 per cent. nitric acid in water, a reagent which does not attack phosphide of iron, which therefore remains white whilst everything is darkened.

When even so little as 0.04 per cent. phosphorus is present it can be detected, and as the phosphorus increases the white areas proportionately increase.

The method of examination described is simple; any intelligent boy in a foundry can use it, and with the aid of the simple microscope, such as I have before me, specially designed for use in the workshop, he can tell within certain limits what phosphorus is actually present.

When no laboratory is available, an instrument of this kind, or one more elaborate, should be found most useful.

The following summary of this lecture indicates the main points of interest, and show, viz.:—

1st. That much of the researches previously published have been confirmed by more recent investigations, and may therefore be considered as established.

2nd. That notably Levey, Saklatwalla, and Wüst have added materially to our knowledge.

3rd. That Levey and myself independently discovered with the aid of the microscope the existence of a sulphocarbide eutectic, the composition of which is not yet known.

4th. That the independent work of Wüst and myself has proved beyond doubt that the eutectic of phosphorettic irons contains about 2 per cent. carbon 6.8 per cent. phosphorus, and 91.2 per cent. iron.

5th. That the microscopic structure of white and grey pig-irons appear to indicate that the eutectic is profoundly altered in composition in grey iron during cooling from 1,000 degrees C., and that it parts with much of its carbon to the surrounding mass, and finally when cold contains probably not more than 0.3 per cent. carbon.

6th. That the auto-sulphur prints taken from cast irons, steel, etc., not only indicate how the sulphur is distributed, but show the relative amount of sulphur actually present.

7th. That by a very simple polishing and etching process and the use of a very simple microscope, the metal worker can tell whether the phosphorus present is much or little, and easily distinguish the difference between Cleveland, Staffordshire and hematite pig-irons, and determine whether grey hematite pig-iron is high or low in phosphorus.

At the conclusion of his lecture MR. STEAD said:—Someone remarked just now that a year or two would be required to clear up some of these points. I should rather say a century or two. (Hear, hear.) Our grandchildren, no doubt, will say of us, "How those British foundrymen were grovelling about in the mud. How little they knew!" And no doubt their grandchildren will say the same thing of them. Investigation of this kind is like exploring a river to find its source. One passes tributaries, and would like to explore them, but all one can do is to make a note of them for future exploration and still press on toward the far-distant source. Practically all the photographs I have shown you are magnified only about 50 times, and usually I find that quite sufficient for a lecture of this character. I have endeavoured to show you how observations can be aided by very simple means. My object has been to encourage you to observe. The great thing in science is observation. I suggest that your members when they come to a very knotty problem, something which they have endeavoured in vain to understand, should ask questions, and that these questions should be tabulated and sent out to members to be discussed at their meetings during the year. You should come to your Association with any such difficulties and say, "Here is a problem; solve it if you can." (Applause.)

The PRESIDENT: As I predicted, we have had a most interesting and practical paper from Mr. Stead. Although he is one of the greatest of metallurgical experts in the world, he has been able to give us many really practical points which we can use with advantage in the foundry. We are under a special obligation to Mr. Stead for having kindly consented to give us this lecture, as he is on his holidays and about to go on a motor tour. We will not detain him any longer, but we cannot let him go without a hearty vote of thanks for his kindness and considerateness, and for the hard work which it must have cost him to give us this admirable, interesting, and useful lecture. (Applause.)

MR. PILKINGTON: I should very much like to second this vote of thanks, because when I was at the May meeting of the Iron and Steel Institute I spoke to Mr. Stead about this matter of the lecture, and he at once said without any hesitation at all that he would give it if possible, though our meeting would come during his holidays. We are very much obliged to Mr. Stead, and we heartily appreciate the kind way in which he has acceded to our request to give us this lecture. It is with pleasure I second the motion.

The motion was carried with applause.

MR. STEAD: I thank you, gentlemen, and I must tell you that it gives me a special pleasure to meet you in Newcastle, for I am a Tyneside lad myself. I was born at Howden, and served my time

at Newcastle-on-Tyne learning my business. I am not a member of this Association, but if you think I have the necessary qualification—(laughter)—I should be very glad for someone to propose me as a member. I am a member of the Foundry Association in America, but I am not a member of this Association—I suppose simply because I have not been asked.

MR. BUCHANAN thereupon proposed that Mr. Stead be elected a honorary member of this Association.

The motion was carried unanimously.

MR. R. W. KENYON (Accrington) then read the following paper :—

ON SECURING THE CO-OPERATION OF THE WORKMAN IN THE IMPROVEMENT OF WORKSHOP METHODS, ETC.

The question of the relations between Capital and Labour is one which has been discussed at such length on so many occasions, and from such various standpoints, that I propose to say only a little with regard to it, but that little I must say, because it affects the subject of my paper.

We know that those who are employers are regarded more or less as "The Capitalists" by those whom they employ, and whilst they are generally found ready to maintain that the interests of Capital and Labour are closely united, yet I think it must be conceded that the employé is not always willing to admit the truth of this contention. The workman generally, I believe, contends that the employer always keeps his own interests in the front place, and that the interests of his workmen are such a secondary consideration as to be in danger of being overlooked altogether; that, in fact, so far from the interests of labour being in any way identical with those of capital, they are opposed, and that labour is merely an instrument for the purpose of producing more wealth to be appropriated entirely by capital. Employer though I am, I am not prepared to deny that there is a substratum of truth in the contention. I have for years held that the worker ought to have some share in the wealth he helps to create, beyond his bare wage, and as self-interest is with the best of us an incentive to put forth the best of which we are capable, so it would be a natural corollary that the interest of the worker in the profits would produce increased results. Such would appear only a reasonable thing to expect. I am prepared to be met with the objection that profit-sharing has been tried and found wanting, and that in cases where they have been admitted to a share of the profits no improvement in the behaviour or efforts of the workmen has been noticeable, and that the final result of the experiment has been that the employer has simply made a present of part of his profit without any return being made for it. The sharing of profits with workmen, however, is not what I propose to discuss to-day. I merely mention the subject as an illustration of my personal attitude to the workmen, and as providing

MR. R. W. KENYON.

the key to the efforts in which, in conjunction with the firm to which I have the honour to belong, I have been engaged during many years.

The interest of the workman has in the past been largely confined to doing the work he was told to do, and in the manner in which he was told to do it, and when a man has been through a long period of years thus "cribbed, cabined, and confined," we cannot expect him at once to throw off the shackles which have limited his action, and to become a thinker instead of an automaton.

A story is told of the founder of a well-known firm which affords a good illustra-

tion of the manner in which the workman was regarded in the days of my apprenticeship. This employer, passing through the fitting shop one day, found a man standing at his bench deep in thought, and asked, "What are you doing?" The man, who, as a matter of fact, had his mind intent on his work, began to reply, "I was just thinking ——," when he was interrupted with the rejoinder, "Look here, I'll do the thinking here—you are paid to work." Undoubtedly this was the attitude of manager to workman in those days, and it would be interesting to discover to what extent it has been modified during the forty years which have since elapsed. So far from one man only being paid to think, I say, let us have a shop full of thinkers—the more the better—for in my experience you get better results from the thinker than from the mere automaton. This truth was grasped long ago by our German competitors and in the United States, and one is pleased to know that our own country has realised its truth also, as is evidenced by the opportunities for the development of the thinking and reasoning powers now placed within the reach of all who have the ambition to improve themselves.

I will deal now with my subject on three lines :—

1st. What are the duties of a workman towards his employer?

2nd. Is co-operation between employer and employed desirable and possible? If so, how is it to be secured?

3rd. To outline the scheme in operation in our own works in Accrington.

As to the first clause, the employer engages to pay the workman a stipulated wage for which an equivalent must be returned in work. The question arises as to what is a proper equivalent. I have heard it maintained that it is the duty of every foreman and every workman, not only to perform the allotted daily routine, but to exercise his thinking powers to the utmost for the furtherance of his employer's interests. This is open to contention. We will take the case of a moderate sized works with, say, eight foremen and 200 men. Amongst the foremen we will take it that there are six, each with a similar number of men under him, and with responsibilities about equal. These foremen will be paid equal salaries. Now it is most unlikely that the ability of all those men will be as equal as their wages and their responsibilities. There is sure to be one man at least of a more thoughtful turn of mind than the others, to whom the surmounting of a difficulty is its own reward. Such a man would be capable of producing results superior to the others. Now, is it not unreasonable to expect that this man will devote his abilities for the benefit of his employer, whilst the other foremen merely perform their ordinary routine duties? The same applies with equal force to the workman. It might be urged that such a man could have an advance of wages, but those who have had experience of workmen, and of the jealousy which exists amongst them, know how difficult, and even dangerous, such a course is. Therefore, I think I am justified in setting it down as a principle that we are not entitled to expect from either workman or foreman more than we get from any other man to whom a similar wage is paid.

In regard to the second clause—"Is co-operation desirable and possible, and if so, how is it to be secured?"—he would either be a vain man, or a very short-sighted man, no matter what his abilities were, who thought that there was no one in his works able to make suggestions which would be more valuable than his own. Undoubtedly, there must be somewhere amongst our workmen a latent talent which, if fostered, would be capable of producing valuable results. Look around our large workshops, and think how many have been founded by men who were once ordinary workmen. As an instance, take the Tangyes, of Birmingham. Why should we suppose we have no such men now? If there is such latent talent, then it ought to be developed; and, therefore, I reply that co-operation between the employer and the workman is a desirable object to attain.

To my next point—"Is co-operation possible?"—I reply "No" and "Yes." No, if the employer holds that he is entitled to the best that every man is capable of, and that best for merely the weekly wage of the ordinary man. As an employer, I say it is unreasonable and it is unjust. With all his faults, the British workman has generally a sense of justice, and when he feels there is injustice he is not likely to co-operate. But I reply, "Yes, co-operation is possible if it is on just terms; if the interests of the workman are taken into consideration, and an acknowledgment of a practical and substantial kind is made according to the services rendered." The first step is the establishment of confidence; the second, that the acknowledgment or reward shall be made on a business-like

principle, and not be a kind of charity. With regard to the establishment of confidence, this is a long process, and there is only one way to secure it; that is by unswerving fidelity in every case to the path of absolute fairness and honesty. There must be no tricks, no subterfuges, no petty meannesses, no sharp practices, if the confidence of the workman is to be secured. It must be remembered that there are two points of view, that of the master and that of the man, and every subject, every trifle, must be examined from both standpoints, and every decision must be that which harmonises best with both. To some extent, it is the sharp tricks of the so-called "smart" business man that have fostered the distrust which the average workman feels for the average employer. As to the other point, that of making the reward on a business principle, you will see what I mean in what follows later.

Now I will deal with the third point, and outline the scheme in operation at Ewbank Works, Accrington.

From the time when I first worked at the lathe, in 1866, followed in 1869 by a transference to the pattern bench, I have always had strong sympathy with the workman, and it is no doubt due to my close association during those years in a small works with a small band of men, men whom I can, after a lapse of close on 40 years, look back upon as a very good type of the sturdy, honest, and capable British workman, that I can attribute my sympathetic attitude. During the years since I first held a position of responsibility I have made it my aim to try to be as just to the workman as to the employer. I have tried to view things from the workman's point of view as well as my own, as also do my co-directors, and this, perhaps, may in some measure account for the fact that in our small works we have, out of 180 workmen, clerks, and travellers, 59 men, or practically one-third, the average of whose years of service is 21 years.

I think a record like this testifies to the good feeling and the confidence existing between the firm and those who assist in its operations.

The first effort in the attempt to secure co-operation was made about 30 years ago, when we offered to each foreman a bonus, paid monthly, on the saving in his department. For instance, a fair average price per ton of castings produced, a price for joiner's work, for mechanic's work, for smith's work, etc., for each article we made was agreed upon; cost books were kept, weekly accounts rendered and a monthly balance made, and the bonus paid when earned.

A further attempt was introduced in 1889, when we commenced in two departments a bonus system for the men. There has been much talk of late years of the American premium system, and much credit has been given to our American cousins for it; but when I suggested to my firm, in 1889, that we should commence the bonus system, which I think is identical with the American premium system, I had never heard such a thing even hinted at. To me it would be of peculiar interest to know when the American premium system was first introduced. By our bonus system, a price was fixed for which the article ought to be produced, and one-half of any saving in cost of production, that is in wages, was to be paid to the workmen. This system has been in operation without a break since 1889, and although, like every other thing in this work-a-day world, it has its drawbacks, it has been very satisfactory in those departments where piecework was not already in operation. A recent further development of this system has been the inclusion of the tool shop foreman, who now receives a percentage on the total amount of bonus earned by the whole of the foremen throughout the works.

Following this came a further innovation in 1896. We had had in force for some considerable time a system of fines for late attendance of pieceworkers and for misconduct (such as smoking in the works, breaking rules with regard to time checks, and so on), and these fines had previously been appropriated by the firm. But in 1896 it was felt that it was undesirable that the firm should be making money at the expense of the workmen, and it was then decided to found a "Fine Fund," to which all fines should be paid, this "Fine Fund" in future to be devoted to two purposes; first, to pay doctors' bills either for accidents to any men, or sickness arising out of the employment; and secondly, to make contributions to workmen who had been absent from work through sickness or accident. For this purpose a committee of one man from each department was asked to co-operate with the works manager to decide when help should be given, and to what extent. As under the Workmen's Compensation Act the workman now receives compensation from the insurance company for absence resulting from accident, the Fine

Fund is now applied entirely to cases of sickness. This fund has during the last eleven years been of very great service in both these respects, and has given great satisfaction to the men. The firm now insists that every man who meets with an accident shall be attended by a duly qualified medical man without delay, the bill being paid out of the Fine Fund.

And now I come to the last, and not the least important, part of my paper, and that is what we call our "awards for suggestions" scheme.

At its inception, this scheme was not original; it was based upon an American scheme. But in its present shape I think it is essentially original, and also a more reasonable plan than the one from which it originated.

In 1903, Mr. C. B. Auel, who was for some years assistant to the general manager of the British Westinghouse Company, at Trafford Park, Manchester, and is now with the American Westinghouse Company, in Pittsburg, U.S.A., suggested that our business was essentially one in which we ought to be able to get good suggestions from the men. He mentioned that the National Cash Register Company, of Dayton, Ohio, U.S.A., had a system in operation for remunerating the men for suggestions, and advised me to get into correspondence with the company. I did so, and became an enthusiastic admirer of the company's principle of giving rewards to the men for suggestions for improvements. I found that the acceptance or rejection of the suggestions and the amount of the award were decided upon by a committee, and that a sum of about $1,500 was available annually for prizes, the amount of the award being limited as far as I could gather to $50.00 in any single case—that is about £10. We followed the Dayton Company's method very closely in our original plan, but knowing the scepticism of the British workman when the employer offers him a gift, we thought that it would be advisable, in order to secure his sympathetic co-operation, to have a committee on which there should be representatives of the workmen equal in number to the representatives of the employers. Our original method was that we would have a half-yearly competition, and we arranged that all suggestions sent in should be dealt with by the committee referred to. This committee was composed of seven representing the employers and seven representing the men; the seven for the employers being three directors, the secretary, and three foremen, and the seven representing the men being one man selected by the men from each of seven departments. This system was found at the outset to work satisfactorily. The voting as to the amount of the award was by ballot, and it is a singular fact that in all cases when the amounts suggested for the successful competitors were examined, the amounts suggested by the directors were always in excess of those suggested by the foremen and the men. Naturally there were some suggestions which were not considered of sufficient merit to be adopted, but on the whole the effort was fairly successful. The committee meetings were always held in the evening, and in order that the men on the committee might not feel that their time was being wasted, the directors arranged that they should be paid at their usual rate of wages for all time spent at the committee meetings. A little over two years ago an incident occurred which showed that however good it was in theory to have the workmen themselves sitting on the adjudicating committee, there were objections to it in practice. One of the men told a director that he had a suggestion to make with regard to his own work, by which he could do at least 50 per cent. more work if certain alterations were made in the arrangement of certain machine tools. He was told to send in his suggestion to the committee, but this he refused to do. He said that men who had made suggestions had suffered so much from the chaff and humbug of some of the men who either had not the brains to send in suggestions or were too indifferent to do so, that if he might not make the suggestion in confidence to the directors he would drop the thing altogether. The matter was considered by the directors, and it was then decided that in future, instead of a half-yearly competition the scheme should be made continuous, that suggestions should be sent in at any time, and that the competitor should himself decide whether the suggestion should be adjudicated upon by the committee, who would be called together for the purpose, or by the directors. It is worthy of note that since then the committee has not once been called together. In every case the directors have been asked to consider the suggestion, and to make the award if the suggestion was considered to be worthy of one.

Posters, which read as follows, are exhibited now in every part of the works, giving particulars of the amended scheme. I would specially draw your attention

to Clauses 3, 4, and 5, because they are the enunciation of a new principle :—

1. We propose in future that suggestions, either for improvements in methods or systems of production or manufacture, or for improvements in articles we manufacture, may be sent in at any time, instead of once in six months, as in the past. The Secretary will, at any time, and in strict confidence, supply the necessary forms on which suggestions are to be made, as in the past.

2. Suggestions may be adjudicated upon in one or two ways, at the option of the person sending in the suggestion, viz. :—

(*a*) It may be sent in as before to the Suggestion Committee, who will decide what award (if any) has to be made. The sealed envelope containing the suggestion may either be left with the Secretary at the office, or sent to him by post. A meeting of the committee will then be convened, and the amount of the award will be settled by the committee as in the past; or,

(*b*) Where publicity is not desired, it may be addressed to the directors, who will treat it as a confidential communication, and will not divulge the name of the person making the suggestion except with his consent or by his desire.

3. Where the scheme is submitted to the directors under paragraph (*b*), and is one for an improvement in methods or system of working or production, the directors will decide upon the merit of the suggestion, and upon what award (if any) shall be made, and they undertake that any sum they award shall be given privately, and no mention made of it in any way except where otherwise desired.

Where no outlay in new machinery, etc., is entailed, and where the cost of altering existing machinery, tools, etc., is not of any moment, the general basis on which the award will be made (should the suggestion be adopted in its entirety by the directors) will be one-half the amount of the total saving effected during a period of two years from the day when the suggestion is put into operation. This amount will be paid quarterly so long as the man who makes the suggestion remains in our employ, but payment will cease if he leaves our employ.

Where considerable modification of the suggestion is necessary to make it practicable, or where special outlay in plant or appliances is required, then a special arrangement will need to be made between the directors and the person making the suggestion.

4. When the suggestion is submitted to the directors under paragraph (*b*), and relates to improvements in the articles already being manufactured by the firm, a special arrangement will need to be entered into in every case between the directors and the person making the suggestion.

5. In any and every case the directors undertake not to make use of any suggestion without first having come to a mutually satisfactory arrangement with the person making such suggestion, except the suggestion is a matter of public knowledge, or the company has already experimented with, or has put into practice, a similar idea, or already has the idea on its own list of improvements to be worked out.

I would again direct your special attention to what I consider is the keynote of our later scheme, and the point where we now differ so materially from the scheme of the National Cash Register Company. In their scheme the amount at disposal for the awards was, as I said before, limited to a certain amount per annum. In our case it is absolutely unlimited, which from the workman's point of view must be a preferable arrangement. The broad principle of our scheme is that the workman shall be entitled to half the savings of the first two years after the scheme has been put into operation, that is when the suggestion relates to a process of manufacture. Where the improvement is in any of the articles we manufacture, and it is considered to be patentable, a patent will be—and in fact has been—taken out at the expense of the company in the joint names of the company and the workman, and a royalty paid on each article made. I call this a really business-like principle—the award is not a matter of charity, neither does it leave room for any dissatisfaction with the award. We give half the savings for two years, and so whether the award is £1 or £1,000 depends entirely on the suggestion itself, and thus the man fixes the amount of his award.

Whilst we have not been flooded with suggestions, yet I think we have no reason to be dissatisfied with the results up to now. The drawback under Clause B of Section 2, by which suggestions are made to the directors in confidence, is that the workmen generally are in ignorance of what is being done, and so that stimulus is lacking which was provided by the old scheme when the suggestions were sent to the committee and the awards publicly made. I have asked my co-directors to alter this arrangement, and they are willing that in future a half-yearly announcement shall be made which, whilst concealing identities, shall give the men a general idea as to the suggestions received, the departments from which they come, and the value of the award. I am inclined to think that at some later day

when ignorant jealousy has died down and the thinking men in our works have experienced the monetary advantages of our scheme it would be a good plan to adopt another point of the American scheme, and to issue a handsome diploma to all successful competitors to serve as a momento of their achievement.

I think this is a fairly complete account of what we have done in the Ewbank Works during the last 18 years in the way of securing the co-operation of the workman, and I hope that none of you who have done me the honour of listening to what I have had to say will feel that your time has been badly spent.

Discussion.

The PRESIDENT: Gentlemen, we have listened to a paper full of possibilities and of the greatest interest. We all know that without co-operation of some kind or other it is impossible to do good work of any kind, especially in a foundry. Co-operation is entirely a question of degree, and we all want to foster it to the greatest possible degree. The discussion is now open to anyone who likes to take part in it.

MR. BUCHANAN: I agree with the President that this is a most interesting subject. I am afraid it is one to which I have not given a great deal of study, though I served for some time on a works committee. Our experience was that the men were afraid to tell what they knew or even to make suggestions, and one of the principal fears in their minds was, I think, with regard to the influence it would have upon their relation with the foremen. I have heard it suggested that before the works committee scheme was instituted, men would sometimes make a suggestion, and it would be pooh-poohed by those above them at first, and be brought out about twelve months afterwards by their superiors as their own original idea. I have heard instances of large works in which the scheme was talked about as having infused great enthusiasm. But I have heard of cases like this: an idea came to a man, he immediately suggested it to the employer, the employer speedily adopted it, and the result was the man did about twice as much work as before, and got less money. The person who informed me about it, told me that that mistake on the part of the employer stopped any advance in processes for more than ten years. That was a misplaced greed, which defeated its own end. As regards rewards for advancing processes, there is no mistake that there is room for a scheme which will enlist employers and workmen together in co-operation to produce the best results, more than is the case at present. It is all very well to say that the interests of employer and employed are identical, but there is undoubtedly a distinct want of confidence in many works that there is going to be fair play. The men have not confidence in the employer, and in many cases the employer is not confident that the men will deal fairly with him. But, as the President has said, it is an endless question.

MR. GIMSON: I agree with every word of the paper, to the extent of thinking that the ideas were extremely good and right, if we could succeed in carrying them out. But I see one or two serious difficulties in the way. As regards foundrymen, the question of Trades Unionism comes in rather seriously. I know that we ought not to discuss that fear, and I am not going to discuss it. (Hear, hear.) I am, personally, in favour of the principle of Trades Unionism, but with the employer it is perfectly natural to consider how the influence of Trades Unionism affects such a question as this. In foundries, the Trade Union has strong objections to one or two of the things suggested by Mr. Kenyon. They will not allow anything in the nature of a bonus system or anything in the nature of piecework, so that while the scheme might be carried out in any other part of our works, it could not be carried out in the foundries, except possibly with the very small number of men who do not happen to belong to a society. That is a question which we cannot discuss here; but, obviously, it bears very closely upon the question of co-operation. I trust the time will come when we shall have more complete co-operation between employers and employed.

MR. DALRYMPLE (Sunderland): One thing most desirable in the foundry is that men should be judged by the results of their work. I think it is the best way to get good work out of the men, and to get a good return. I could instance one or two examples myself. We have a class of work, a speciality, and there is a great deal of it. We tried it with one set of foremen, and it worked out at 9d. an hour; with another set of foremen it worked out at 1s. 3d. per hour; 1s. 3d. was what the men could earn. If this system of judging men by results were consistently brought in between the foremen and the workmen, very many of the troubles you have would disappear.

MR. R. CARRICK: While Mr. Kenyon was speaking, an incident in my own experience came into my mind. When I was a workman, I was employed a long time in Canada with a well-known company. We had a small cylinder in the shop which had given us a great deal of trouble. After a while, I was tried on this cylinder, and in a little while I got rid of that trouble. Not long after I had got the thing to go smoothly, the foreman came to me and said: "You will start to-morrow morning on piece!" Well, I did not like it, and I threw up my job. In places like that men do not get much encouragement to suggest improvements. The problem is a very difficult one, and, after all, it resolves itself into a question of confidence between employer and employed. My first position as a foreman was held in this city of Newcastle-on-Tyne. It was a repetition shop, and I noted carefully the length of time it took on the various jobs on which the men were working. Then I would say to them: "The last time we made this piece of work it took so much time. Now you can go on this system. If it took you 24 hours, and you can do it in less, whatever time you knock off you shall have half of." But the Trade Union was soon crying out about the amount of the wages the men were drawing. It is a very complex question and requires a great deal of consideration. With regard to employers and foremen, and their treatment of their men, too often they are treated as men who have not got intellects. I have adopted a scheme in my present shop by which all my foundries have the benefit of all the literature I get bearing upon their work. I have appointed one of the lads as librarian in the shop and have told him to hand out to the other boys that literature. To my mind that is going to be the salvation of the foundry. If we can educate them in that way we shall be more likely to do good and to get their co-operation in the future. We must look to the education of those who are growing up. (Hear, hear.)

MR. PILKINGTON: I had not meant to join in this discussion because it was approaching a subject that is rather delicate and one which I would rather keep away from. I would rather not talk about some things but would prefer with regard to them to do a little bit of thinking. There is a little suggestion that we are putting all the wooing that requires to be done upon the employer, and not on the employé. It seems that as a matter of experience the employer is universally mistrusted. In small works, where he comes in direct contact with the men it is not so much a problem as in the large works which we have at the present day. I do not see how the method suggested can be brought into practical operation in a works like that. Indeed, many methods have been tried to get more in touch with the men, but you must not forget that in these large works there is an intervening force which had best not be mentioned. It is best for this Institute not to touch upon that question. While we have a right to talk about methods of work in the shop and so on we had better leave Trade Unionism alone. I will content myself with suggesting that it is not right that all the wooing should come from one side, but there is no doubt that the deep distrust which exists in some cases on either side is very much to be deplored, and is a great hindrance to progress.

MR. J. SMITH (South Shields): To my mind the one thing that will make this matter clear and make everybody satisfied is piecework. For the last ten years I have had control of a shop that is working piecework. Great benefit is being derived from the large concessions which have been made by other firms. If you can get a certain number of men to work in harmony with the management of the foundry you will be successful. A little while ago we had an enquiry for a bed-plate of over 10 tons. We allowed seven days for casting, and the firm who wanted the bed-plate did not think it possible to do it in the time. They suggested that they should send a foreman into our place to see how this thing was going to be made so quickly. He saw the job through, and I asked him how long it would take at his works. The difference between making it at our works and at theirs was exactly three weeks. To my mind this success was due to piecework. Provided the man at the head of affairs knows what the value of a job is and the workman is satisfied with the foreman—(laughter)—that to my mind is the finest system there is for the foundry.

The PRESIDENT: Gentlemen, this is a very interesting subject, but it is now time to draw our meeting to a close.

The PRESIDENT proposed a hearty vote of thanks to Mr. Kenyon for his paper, which proposal was seconded by MR. BUCHANAN.

MR. KENYON, in reply, said: Mr. President and Gentlemen, I am very much obliged to you for your appreciation of my efforts and for the manner in which you have listened to me. Perhaps you will allow me two or three minutes more, as I should like to reply to some of the questions, all of which were justified. Mr. Buchanan referred to the difficulty of the foreman. I admit there is a difficulty in a man sending a suggestion over the head of his foreman. That is the reason why we insisted upon having suggestions sent direct to the directors. With regard to Trade Unionism I may say that we are not troubled in that way. At the last Convention I had a conversation with Mr. Cook about this matter. I think his system is an improvement on our own. It was something like this; that you fix the time of a certain job, and if the man finishes the job in less time you give him a bonus, say 20 per cent. extra on his wage. At the moment I said that is just equivalent to our scheme, but I have been working it out since, and I find him practically giving 75 per cent. to the man, while the firm gets 25 per cent., and I am inclined to think that is not too liberal to the workmen. Even in a Trade Union shop I think that system might apply. In regard to Mr. Carrick's experience in Canada there is a case similar to that one which I have always had in my mind. It is an instance of what happens when a large firm has made it its duty to cut down prices in every possible case. A man once told me, in answer to a question, that he could make 50s. a week if he liked, but he knew very well that if he made more than 35s. in a short time he would have his prices dropped, so he just made up his mind to keep on earning 35s. a week as long as he stopped there and not a penny more. When you find that that is the attitude of a big employer are you surprised that men resort to little tricks and subterfuges, and are content with average work and with just making sure of average pay?

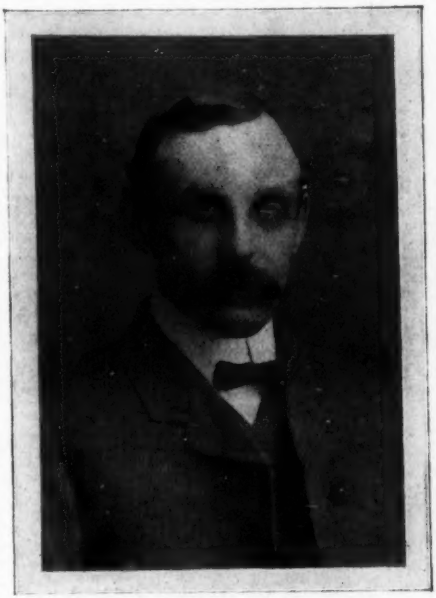
MR. R. MASON: Before this meeting breaks up I think we should take note of the proposal of Mr. Stead with regard to communicating to the Association difficulties which crop up daily in the foundry. These, I think, should be noticed and sent to the Secretary, so that arrangements could be made for discussing them. There is a feeling in the Association that there should be more discussion of practical matters, and I think it would be a good thing to have a sub-committee to draw up a scheme such as Mr. Stead suggested. I suggest that members be invited to communicate to the Committee difficulties met with in the foundry, and that these should be discussed by a sub-committee and submitted to the Council.

The PRESIDENT: I will undertake that this suggestion shall be brought before the Council at its next meeting. (Applause.)

This concluded the first day's session.

Visit to Wallsend.

After luncheon, the members took steamer at Newcastle Quay, and paid a visit to the North-Eastern Marine Engineering Works, at Wallsend. Thence they proceeded to the Tyne Dock by steamer, and afterwards to the North-Eastern Foundry. The visitors were entertained to tea by the directors.



MR. F. J. COOK.

The new President of the British Foundrymen's Association.

In the evening the visitors crossed from South Shields to Tynemouth and spent a pleasant evening there, returning to Newcastle by the electric railway.

The New President.

Mr. F. J. Cook, the new President of the British Foundrymen's Association, may almost be said to have been born a foundryman. He is a native of the "Black Country," and his family for three generations has been connected with the mining and the iron-rolling industries of that district.

His father and grandfather were closely associated with the famous Bloomfield Works. Born at Deepfields, near Wolverhampton, in 1870, Mr. Cook passed his school life at Willenhall and Wolverhampton. His apprenticeship was served in the works of Messrs. Joseph Evans & Sons, the Culwell Iron Foundry, Wolverhampton. Concurrently he studied the theory of his trade in the evening classes of the Wolverhampton Free Library and School of Art.

In these he won many distinctions, including special students' prizes for the greatest number of passes in the Government examination, his principal successes being in engineering subjects, machine construction and drawing, and electricity. Following his apprenticeship he entered the service of Messrs. Belliss & Morcom, the well-known Birmingham engineering firm. During eight years of work in the drawing office he designed and directed the erection of extensions of the works and of a completely new factory, in which were included two iron foundries, pattern shops, brass foundries, and other departments.

In 1899 he was appointed foundry manager, and he still holds that position.

Mr. Cook has been for several years a member of the Council of the Birmingham Association of Mechanical Engineers, and last year was awarded the Society's diploma for the best paper of the session, his subject being "The Tensile Testing of Cast Iron." He is also a member of the Birmingham Metallurgical Society. He was one of the founders of the British Foundrymen's Association, and has completed two years of office as the second Vice-President. He now passes by the unanimous vote of his colleagues to the Presidential chair.

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(The further proceedings and papers will appear in the November FOUNDRY TRADE JOURNAL.)

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MESSRS. J. VENABLES and W. E. TOMPKINS, malleable iron founders, Walsall, Staffs., trading under the style of Parkes & Company, have dissolved partnership.

OXY-ACETYLENE WELDING.*

———

BY G. H. TAYLOR.

WITH the discovery of the oxy-acetylene blow pipe the metallurgist found an apparatus that at once solved a very difficult problem; namely, a heat-producing agent of great intensity, of extreme flexibility, and at relatively low cost.

Before going into a detailed description of this apparatus a brief outline of other high heat-producing agents will be given.

Probably the first burner of any value was that of Bunsen, using carburetted hydrogen or ordinary illuminating gas and air. This, owing to its relatively low heat, was of little value to many operators, and so a natural step was to use pure hydrogen. At once the great value of this was recognised and the oxy-hydrogen burner came into general use, more particularly in Europe.

With this flame the autogenous welding of steel and iron became practical, but was limited to work on metals about ¼ in. in thickness. One of the greatest difficulties lay in the adjustment of the burners, for the appearance of the flame changed very slightly with widely differing proportions of oxygen; this, of course, resulted in an operator having to depend on the appearance of his work to tell him whether or not he was using an excess of oxygen, and a very slight excess affects the strength of the joint enormously.

The electric arc has also been used extensively for autogenous welding, and is, without doubt, extremely valuable in certain lines, particularly to the foundryman, who by its use can readily close up shrinkage cracks, sand holes, etc.

Too much dependence on the strength of an arc welded joint cannot be made, however, for as a usual thing the metal is left extremely hard. In working with the arc care has to be taken not to expose the skin, for the chemical rays are so intense that a very painful sunburn can be obtained in from 10 to 15 minutes; hence all operators wear gloves and mask, and are careful to keep covered up.

The resistance or Thompson method of electric welding has many advantages over the arc method, there being no danger from chemical rays and an entire absence of the blinding light of the arc. It is distinctly a machine method, however, inasmuch as anything to be welded must be put through a suitable machine.

* Read before the American Foundrymen's Association.

Another valuable heat-producing agent is found in Thermit, but this has little application for commercial work outside of the foundry or for breakdowns.

In the oxy-acetylene process we have, however, practically all the advantages of the previously stated methods, and an absence of their disadvantages, for here we have the intensity of the arc with the flexibility of the blow pipe and an entire absence of dangerous rays.

An additional advantage is found in the chemical nature of the flame, which is composed of an inner cone having a temperature of over 6,300 degrees Fahr., and a relatively cooler envelope or brush composed of hydrogen and water vapour, which not only protects the heat of the inner cone, but also protects the welded metal from oxidation by preventing contact with the air when in a molten state. When it is remembered that fire brick can be made to melt and run like water the great heat of this flame will be appreciated.

Theoretically, it requires $2\frac{1}{2}$ volumes of oxygen to combine with 1 volume of acetylene, but in practice the burners are designed to supply from 1.3 to 1.8 volumes of oxygen to 1 volume of acetylene, and the balance is obtained from the surrounding air. The burners are designed on the well known injector principle, but there are two types at present on the market known as the high-pressure and low-pressure systems; which means that in one case the acetylene is supplied at a very much higher pressure than in the other. The oxygen in both systems, however, remains at practically the same pressure.

It will, of course, be appreciated that where the acetylene is forced into the oxygen stream a better mixture will be obtained, and necessarily a more perfect and economical flame. The high-pressure burners have another decided advantage, in that they are of much simpler design than the low-pressure, so are not so liable to get out of order. Still another and very great advantage is that removable tips of different sizes can be used on the high-pressure burners, so that one blow pipe can be used properly, on many thicknesses of metal, while in the case of the low-pressure system a different blow pipe must be used for each thickness of metal.

The next point which naturally arises is the source and cost of the necessary gases. Acetylene, as is well known, is made from a product of the electric furnace called calcium carbide (CaC2) in contact with water, and in properly designed generators the gas is only produced as needed, and no storage holder is required outside of the usual small one, which is an integral part of the machine.

After the burners have been connected by suitable tubing to the sources of gas, the acetylene is turned on and lighted; the oxygen is then turned on through a previously set reducing valve, and either (acetylene or oxygen) adjusted until a proper flame is obtained. Owing to the great change in the appearance of the flame, not the slightest difficulty is experienced in adjusting or in recognising the proper flame when obtained.

The pieces of metal to be welded, having previously had their edges dressed or bevelled off sufficiently to permit the flame to strike the bottom, are set up in the required position and the blow pipe is applied at one point. A very short time after the flame has been applied ($2\frac{1}{2}$ seconds for $\frac{1}{16}$ in. steel) the metal begins to run; the operator then holds a stick or wire of the same material he is welding in such a way that in melting it will drop down on the bevelled portion of the pieces and so fill up the space. This is repeated continuously along the entire length of the seam. The finished joint then shows an elevation or ridge, caused by the operator melting at each point a slight excess of metal or overloading the joint.

This is done for two reasons—Where the greatest possible strength is required the joint is left as it is and so is stronger than the body metal, being thicker. If a fine finish is desired overloading is necessary, so no hollows or depressions will be found when the surplus is ground or machined off. If properly done it is not possible to detect the joint. So very quickly does the welding progress that the pieces are not even red hot an inch away from the actual welded portion. Not only can all the commercial metals be welded, but almost any combination can be made, such as copper or brass to steel, steel to cast iron, etc.

Aluminium, which has heretofore resisted all attempts at soldering, can be readily welded.

Another and very valuable application of this apparatus is found in the cutting of steel. For this purpose a burner of special construction is necessary and which has in addition to the regular welding flame an opening for pure oxygen under a pressure of 150 lbs.

To cut, the welding flame is adjusted and applied on one edge. As soon as the metal has commenced to melt at that point the high-pressure oxygen is turned on and the molten metal is instantly oxidised and blown away; the burner with

the oxygen still flowing is then moved along the line to be cut and the oxidation progressed continuously. Should the burner be moved too fast, however, the cutting stops. The operator has then to bring the metal up to the melting point again, when the oxygen is again turned on and the cutting continued.

To give some idea of the speed of cutting it might be said that it is possible to cut steel bars 2 in. by 2 in. in 20 seconds, and ½-in. plate at the rate of 45 seconds per foot.

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THE business of the late M. G. Swift, Claremont Iron Works, Halifax, will in future be carried on under the style of George Swift & Sons.

MESSRS. JONES & ATTWOOD, of Stourbridge, are supplying cast-iron distributing pipes to the Birmingham Tame and Rea District Drainage Board, at a cost of £4,054 19s. 10d.

SAMUELSON & COMPANY, LIMITED, engineers, Britannia Works, Banbury, have terminated the exclusive arrangement with Messrs. Briddon & Fowler for the supply of milling machinery to them.

THE PREPARATION OF MOULDING SAND.

THE subject of sand preparation has not received the attention from iron-founders in this country that it deserves. In the production of sound, clean castings with a smooth skin, too much attention cannot be paid to obtaining a grade and mixture of sand suitable for the various classes of work which are being dealt with. In foundries which deal in a very varied class of work and produce castings from thin stove plate to fairly heavy pieces required for large emery grinding and milling machines, etc., and where are used various types of moulding machines, the question has had to be faced. A case in point is the foundry of the London Emery Works Company. After long and careful experiments this firm found three qualities of sand suitable for their work, and by using these in various quantities, arranged five mixtures suitable for the different classes of work and types of machines employed.

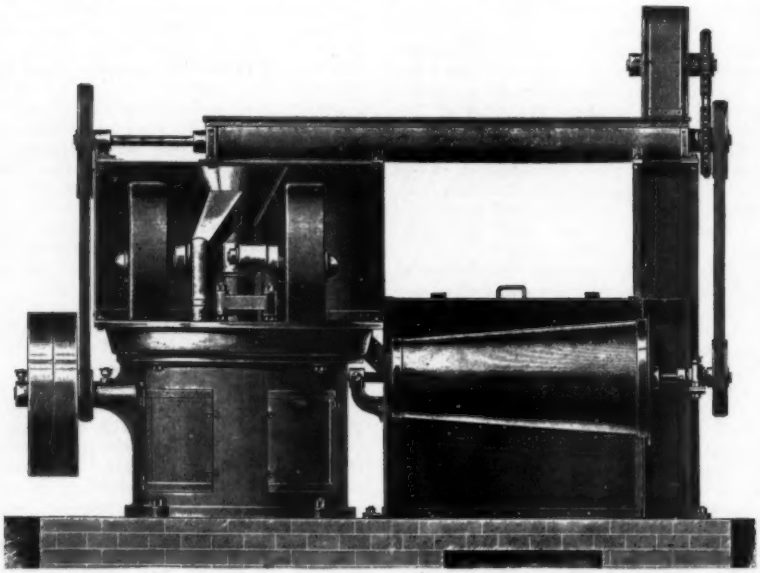


FIG. 1.

The three qualities of sand used, which we will call "A," "B," and "C," may be described as follows:—

"A," a good moulding sand for general purposes.
"B," a loamy moulding sand.
"C," a light moulding sand.

The following is one of the mixtures of facing sand used for heavy castings made on moulding machines and for hand moulding: —

100 parts old sand.
14 parts "A" sand.
8 parts "B" sand.
4 parts "C" sand.
2½ parts coal dust.

is taken to the runners again for further treatment, by the elevator and conveyor.

The mill is completely enclosed with sheet iron, and the sieve with wood, to prevent dust from escaping into the atmosphere. The sieves are exchangeable, in order that different grades of sand can be obtained when required. The capacity of this mill is about 15 cwts. per hour.

It will be readily recognised that to obtain by the process of riddling an intimate mixture of the sands used would

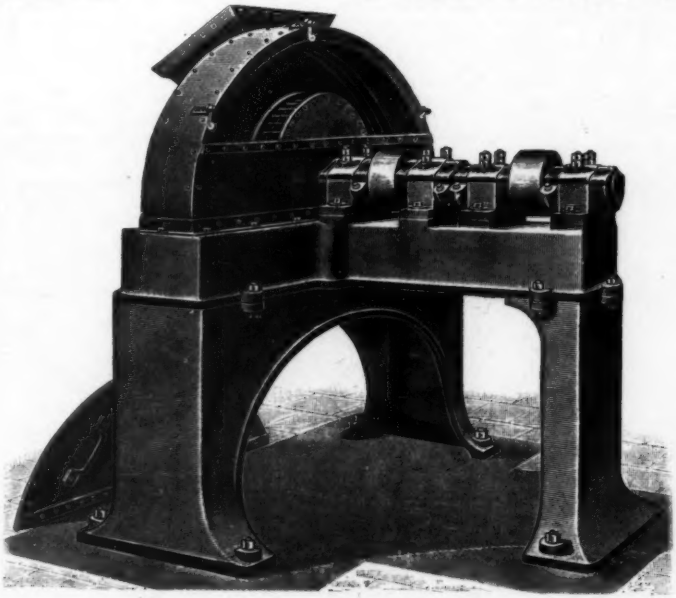


FIG. 2.

Having obtained the qualities of sand suitable for the work, it was found that the grade was not sufficiently fine to give a smooth skin to the castings. The ordinary sand mill in which the sand is milled in a wet condition did not give the desired results, and therefore a mill that would meet the conditions was designed. The result is seen in Fig. 1, which illustrates a grinding mill and sifter combined. The sand is fed to the runners by an elevator and spiral conveyor, but if too coarse it may be fed directly into the mill. It is ground dry, and after milling passes through the rotary sifter into a storage bin underneath. Any material which is too coarse

take a considerable time, even if a power riddle were employed. To meet this difficulty the horizontal sand mixer shown in Fig. 2 was designed. This machine is fitted with two grids, rotating in opposite directions, and the sand fed into the hopper passes through them, and is mixed in a most thorough manner. It not only mixes the various qualities of sand together, but at the same time it opens up the whole by separating each grain of sand from its fellow, and coating it with the clay binder. It has been found that one passage of the sand through this mixer will produce a stronger and more open sand than can be obtained by more than a dozen

passages through a riddle. Before the sand is put through the mixer the heap is cut over with a shovel to obtain a rough mixture of the various qualities. The capacity of this mixer is about 3½ tons of damp sand per hour.

Where the output allows it, the whole of the work can be carried on automatically, and several large installations have been supplied for this purpose by the London Emery Works Company. Fig. 4 shows a modern sand preparing plant of a large capacity. As will be observed, the new sand is delivered in the wet condition in which it is received from the pit, into a rotating drier, and from there is passed into the grinding mill, where it is ground and sifted. It is then carried by elevators and conveyors to a special apparatus that mixes and tempers it with the old sand. The old sand in the meantime is carried to the top of the building, and passing through crushing rollers, is deposited on a reciprocating sieve. The nails, etc., are then taken out by a magnetic separator, when it is ready to be mixed with the new sand in the mixing and tempering apparatus referred to above. Finally, it is passed through a horizontal sand mixer.

The apparatus with crushing rollers, sifter and conveyor is shown in Fig. 3. The crushing rollers are adjusted by strong spiral springs, which give and allow pieces of scrap to pass between the rollers. Underneath the rollers a reciprocating sieve is placed, and this is so arranged that various mesh can be used and changed quite easily. The coarse material is dropped off at the front of the machine, whilst the finished sand is carried to the rear of the apparatus by the conveyor underneath. This machine can either be used in connection with a complete plant or by itself, as desired.

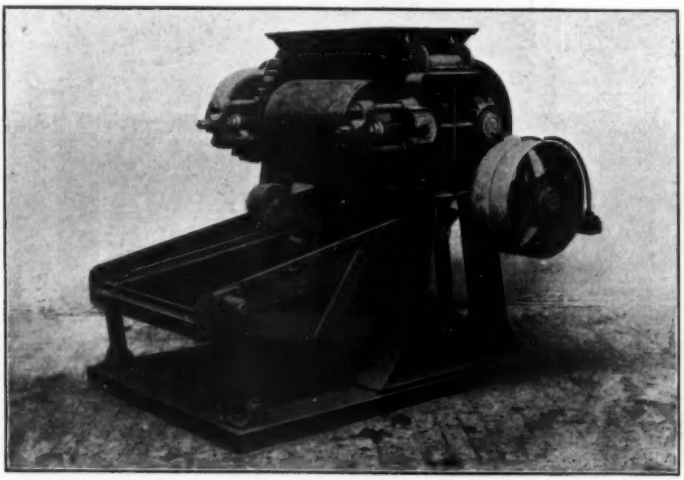


FIG. 3.

THE PYROMETRIC INSTALLATION IN THE GUN SECTION, ROYAL GUN AND CARRIAGE FACTORIES, WOOLWICH.

(*Continued from page* 458, *August.*)

The various sections of the gun department are also in direct telephonic communication with the metallurgical laboratory through a small local exchange board.

Each of the larger sections previously named has an independent instrument room fitted with a simple indicating instrument as shown in Fig. 2.

The temperature of boiling water is taken as a common zero for the temperature scale of the whole of the instruments comprising the installation.

The testing of the zero of the galvanometer is done almost instanter, the same method being adopted throughout the

system. A vessel of boiling water, maintained in a state of ebullition by means of a small gas jet placed underneath, into which vessel a naked thermo-junction is placed, serves as a simple and ready means of securing a constant reference of known temperature. The glass scale upon which the reading beam is thrown being adjustable to the left or right, a slight movement either way, as may be necessitated, serves to re-establish the zero.

paper changed, developed, and fixed. Two recording instruments, a plug board, a telephone, a vessel of boiling water, a bare couple, one or two dishes, and the necessary chemicals for the development, and fixing the record, constitute the equipment of the office.

The standard instruments are calibrated by the arrest representing the boiling point of water as zero, and the freezing points of the following substances:—

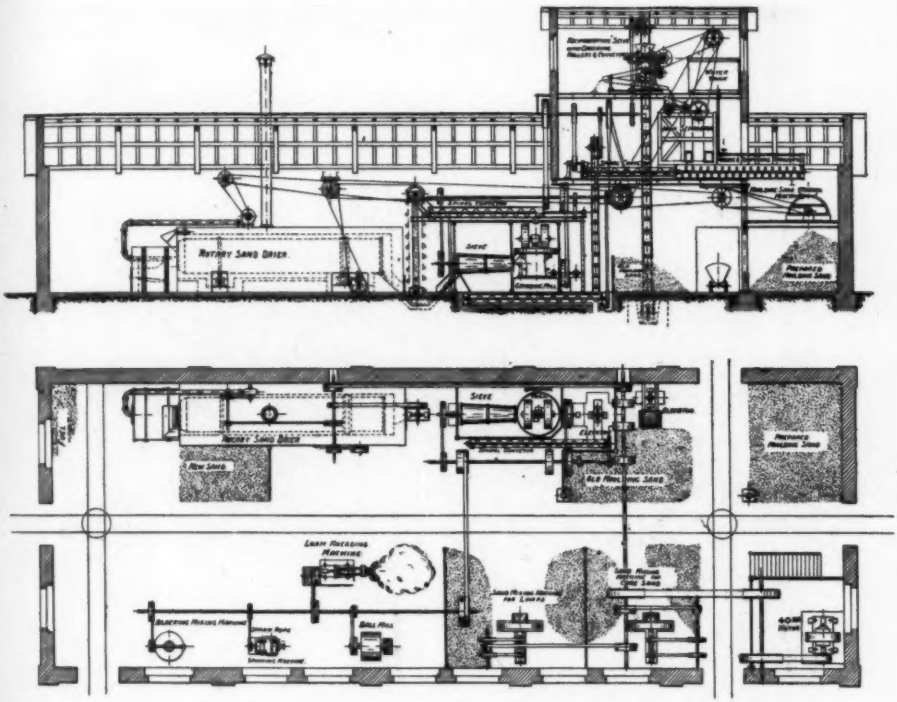


FIG. 4.—ARRANGEMENT OF SAND PREPARING PLANT.

A galvanometer, once installed, may remain for a considerable period without any sensible alteration of the zero.

The leads from the pyrometer cabins to the metallurgical laboratory are of Siemens Brothers "T. 5." flexible twin cable, carried overhead and supported in similar manner to that ordinarily adopted in telephone wiring.

The instrument room in the metallurgical laboratory is so constructed as to be in itself a dark room in which cameras may be opened, and the sensitised bromide

Substance.	Degrees C.	Degrees F.
Tin	232	450
Lead...	327	621
Zinc	419	786
Aluminium	657	1215
Sodium sulphate ...	860	1580
Copper	1084	1983

The metals are ordered from the trade as "especially pure for pyrometer calibra-

tion," the purity of each parcel being ascertained before use by chemical analysis.

A small crucible charged with about 8 ozs. of a metal is placed in a "Fletcher" injector furnace until the contents are molten; a thermo-couple protected by a small porcelain tube sealed at one end is then placed in the molten metal and the gas and blast turned off. Observations are taken of the cooling of the metal, the temperature of solidification being indicated by the arrest in the downward movement of the beam of light upon the glass scale. From the points thus obtained, an interpolation curve is constructed upon squared paper of ample dimensions. Recalibration, though rarely necessary, is effected in the same manner.

In the construction of the recording instrument the glass observation scale is fixed, so far as lateral movement is concerned, as is also the drum; and the relative position of the movable box containing the drum to the body of the camera is also assured by taper pins in the base board of the instrument fitting in the under portion of the base of the movable box.

The sensitised bromide sheet after a twenty-four hours' run on the drum is removed, carefully excluding actinic light, placed in a printing-out frame containing a sheet of plate glass, the inner side of which is painted black, and upon which surface longitudinal and vertical lines are scratched. The exposed paper is then developed, fixed, washed and dried, dated and forwarded to the responsible foreman of the particular section for whom the record is intended. Each sheet represents a day's record in the form of curves of the temperatures of the various forgings treated in the furnaces of the section during the preceding twenty-four hours.

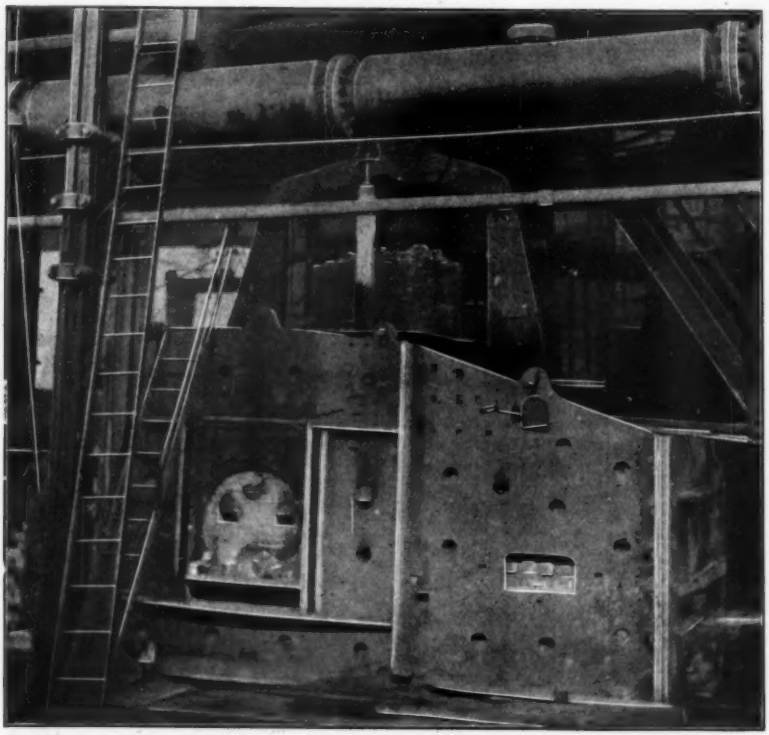


FIG. 10.—MUFFLE SUSPENDED OVER A FORGE RE-HEATING FURNACE.

A simple plug board of a double-pole pattern is employed, to the back of which the respective leads from each furnace are conducted. These leads are of standard wire, gauge No. 18, of high-conductivity tinned copper-wire, insulated with pure and vulcanised india-rubber, taped and braided. Each pair of leads is enclosed in common gas or steam barrel, which is maintained throughout the whole circuit from the furnaces to the pyrometric cabin of each branch, thus ensuring freedom from injury by the corrosive action of any escaping furnace gas or damage by abrasion from ladders, scaffolding, etc., during furnace repairs. The short flexible portion of the leads at each furnace, by which connection is made to the pyrometers in the furnaces, is protected by an asbestos covering, thus preventing any liability of faulty insulation by the scorching of the ordinary coverings. Two plugs suspended

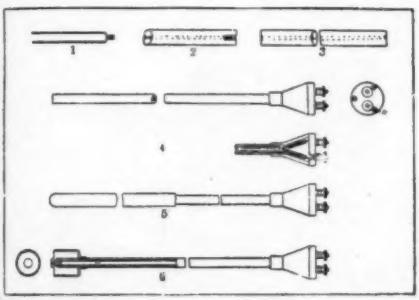


FIG. 11.

on short flexible leads serve to connect either (*a*) the pyrometer cabin, or (*b*) to transmit the thermo-electric current to the recording instrument in the metallurgical laboratory—according to whichever of the two plugs is inserted in the plug holes of the particular leads of the furnace under observation.

The method of ensuring that, as far as possible, the actual temperature of the article heated is ascertained as distinct from the temperature of the furnace itself, is by sheathing the pyrometer tube in a circular muffle of non-conducting material in such a manner that the extreme end of the pyrometer, which is in close proximity to the couple itself, shall be in actual contact with the articles. The muffle ensures the absence of any false reading due to the temperature of the gaseous atmosphere of the furnace being conducted down to the thermo-couple.

The protecting muffles at present in use are of two distinct patterns. For use at the forge re-heating furnaces, the temperature of which approximates 1,110 degrees C. (2,000 degrees F.), these muffles are built up of hollow refractory fireclay cylinders or sleeves, similar to those used to protect the swan-neck stopper bar of the ordinary steel casting ladle. These cylinders are luted together and the whole heavily coated with refractory composition, which is then dried and baked. At the furnaces of the oil-hardening section, there being no occasion for long-sustained high temperatures, the protecting muffle is constructed from mild steel tubing varying according to the size of the furnace from 3 to 6 in. bore, and having centring discs placed at regular intervals along the interior to admit of the insertion of an inner tube concentric with the outer one, and of sufficiently large bore to freely admit the insertion of the pyrometer. The annular space between the inner and outer tubes is tightly packed with well-dried asbestos fibre. These muffles vary in length from 3 to 8 ft., as demanded by the nature of the work and the size of the furnace.

As many as five and six thermo-couples are sometimes inserted in the long vertical furnaces of the oil-hardening section employed in heating the larger forgings forming the inner tubes of the heavier guns. These gun tubes in the larger types of ordnance sometimes exceed 60 ft. in length. The furnaces are gas-heated, and by means of air ports combustion may be regulated with great uniformity, especially when controlled by a number of thermo-junctions placed at regular ascending intervals in the walls of the furnace.

In this type of vertical furnace the muffles protecting the pyrometer are inserted horizontally through the walls of the furnace, and are of such a length as to extend from the walls to the side of the forging being heated. The muffle is supported at the furnace end in a hollow boss or sleeve clamped on to the forging (Fig. 7) in which the muffle tube fits by a rough bayonet joint, the furnace wall forming the support for the muffle at the exposed end. The pyrometer is then inserted in the muffle, care being taken that the extreme end is brought into contact with the forging.

The top stages of the furnaces of the larger description are provided with a simple telephone in communication with the local pyrometer cabin, thus affording no excuse for the furnaceman leaving the stage when nearing the end of the finishing temperature.

Fig. 8 is a reproduction from a photograph of a typical furnace of the above type. At the forge re-heating furnaces, each of which is fitted with independent leads, the sheathing muffle is introduced through a hole in the crown of the furnace roof, being held up and lowered by means of a small winch connected with a wire rope passing over a simple pulley. Such a muffle is shown suspended over a forge re-heating furnace in Fig. 10.

The billet or forging having been placed in the furnace, the muffle is lowered through the roof, the pyrometer inserted in the muffle, the head of the instrument being well above the crown of the roof and protected from radiated heat by a thick sheet of asbestos millboard.

As far as possible the cold-junction of each couple with the pyrometer leads is maintained at an equable temperature as nearly as possible approximating the normal atmospheric temperature; (*a*) by having sufficiently long pyrometers, the wires of the couple being threaded right through from the hot-junction to the head of the instrument, the latter being protected by asbestos screens wherever found necessary; (*b*) the further precaution is taken of calibrating the whole system with an allowance for the average cold-junction temperature of the various pyrometers in use throughout the system as ascertained by thermometric observations.

The details of the actual construction of the pyrometers in use are as follows:—

The ends of the couples are twisted together for a length of $\frac{3}{16}$ of an inch; the twisted junction is then "autogene" soldered by holding the ends in the oxy-hydrogen flame until they become fused to a small globule (1, Fig. 11). This method of securing the ends has proved very efficient, as merely twisting the ends results, after repeated heatings of the same couple, in loose contacts, and leads to false readings from time to time according as the contact happens to be good or indifferent.

The unsecured ends of the wires of the couple are then threaded through the double-drilled porcelain tube of highly refractory clay (3, Fig. 11), care being taken that the wires at each junction of the short lengths of the insulating tubes are not twisted and thereby forming a false contact. This refractory covering, together with the couple wires, is maintained throughout the whole length of a pyrometer, even should this approximate 15 or 16 ft. in length, as is actually the case in the longer forms. The wires in the head are wound into two spirals, which are insulated from each other by

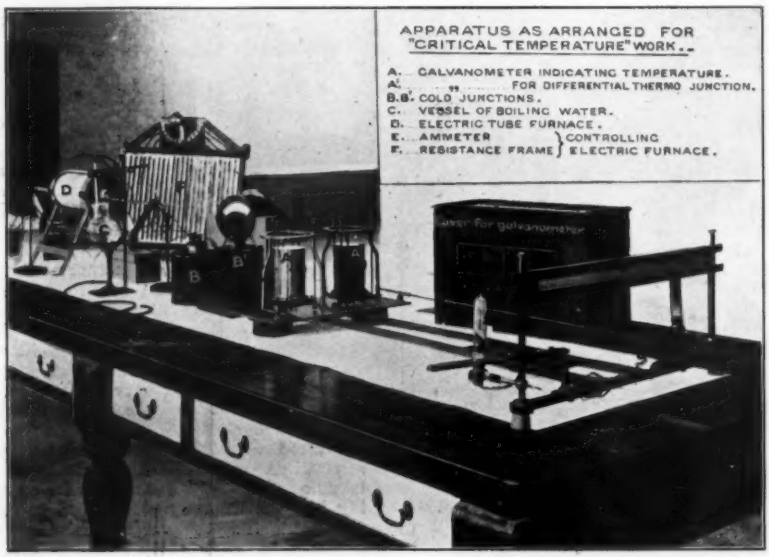

APPARATUS AS ARRANGED FOR
"CRITICAL TEMPERATURE" WORK.
A. GALVANOMETER INDICATING TEMPERATURE.
A'. " FOR DIFFERENTIAL THERMO JUNCTION.
B.B'. COLD JUNCTIONS.
C. VESSEL OF BOILING WATER.
D. ELECTRIC TUBE FURNACE.
E. AMMETER } CONTROLLING
F. RESISTANCE FRAME } ELECTRIC FURNACE.

FIG. 12.

short lengths of rubber tubing. This affords a few inches of spare wire, use of which is made from time to time as necessitated by the re-making of a new junction, etc. (4, Fig. 11).

The double-drilled fireclay tube, immediately at the junction end of the couple, is sawn through longitudinally for a short distance, just sufficient to little more than cover the end of the junction (2, Fig. 11), and thereby preventing liability of any contact between the couple and the welded end of the iron sheath. The head is of cast metal, bored and tapped to fit the iron sheathing. The cover of the head carries the two terminals to which the wires of the couple are connected to the galvanometer leads. It is made of ebonite, and simply fastened by three screws, as shown in 4, Fig. 11. The iron sheathing is ordinary ¾-in. gas barrel. For use at the lead bath the sheathing is a solid-ended tube bored from mild steel rod, and of such length as to be well above the surface of the molten lead, and joined on to a length of gas barrel sufficiently long to ensure the head being well removed from the source of heat. Welded tubes have not proved satisfactory in use at these baths on account of the lead finding its way through after being in use but a short time (5, Fig. 11). The life of the iron sheathing for ordinary furnace work is considerably prolonged by the use of the muffles already mentioned, which, of course, must obviously protect the pyrometer from the more or less oxidising atmosphere in the furnace.

The more secure the protection of the wires of the couple from the influence of the furnace gases, the more immune to changes in thermal value is the wire itself. Upon exposure at long-sustained high temperatures more or less crystallinity of the platinum and iridio-platinum wires takes place. Neither the thermo-electric value nor the conductivity is materially affected by slight changes of this nature.

Excessive crystallinity, however, renders the wire brittle, and necessitates careful handling and frequent inspection when this occurs. The pyrometer should be temporarily withdrawn from use and the couple stripped. The malleability of the wire may be restored by momentarily glowing to incandescence. This is best done by passing a heavy current of electricity through the wire. If this is not convenient, the brittle portion of the wire may be cut off and the wires pulled down from the head, for which purpose the spirally-coiled length at the end of the wire is provided, or failing sufficient length to allow of shortening the wire the whole couple may be transferred end for end.

The gauge of the platinum and the iridio-platinum wires employed throughout the installation in making up the couples is of a uniform size, viz., 25 standard wire gauge, and it was found of considerable advantage to secure a sufficiency of the wires in single coils for the whole installation, with a considerable reserve for the upkeep of the same and for any additional extension of the system that might be made of the pyrometers throughout the system.

There still remains a form of pyrometer which is in daily use for ascertaining shrinkage temperatures in the building up of ordnance, etc., and also for ascertaining the given temperature below which it is not deemed desirable to put further work upon a forging. This couple is similar in most respects to those previously described, but differs in one important feature.

The fire end of the couple terminates in a small exposed platinum plate made up of two small circular discs, $\frac{1}{16}$ of an inch in diameter, of sheet platinum, between which the wires of the couple are lead, and the two discs secured by riveting each to the other. This small plate or disc standing proud of the end of the pyrometer is supported some distance from the end of the tube by a small spiral spring, thus ensuring a good contact when the couple is pressed to the face or side of the heated body. The platinum plate serves as a collecting disc, and being very light and small almost instantly acquires the temperature of the heated mass, and being itself the actual hot-junction proves a most efficient thermo-couple. The general construction of this form of pyrometer will readily be understood by reference to 6, Fig. 12.

Fig. 12 is from a photograph of the installation in the metallurgical laboratory as arranged for critical temperature determinations.

—o—

Mr. E. V. Porter, of Mansion House Chambers, 11, Queen Victoria Street, London, E.C., has been appointed London agent for the oil and gas engines of Walsh & Clark, Limited, Guiseley, Leeds.

The English McKenna Process Company, Limited, have removed their registered and head offices from London to their works, Dock Road, Seacombe, Cheshire.

CORRESPONDENCE AND QUERIES.

SAND FOR ALUMINIUM ORNAMENTS.

To the Editor of the FOUNDRY TRADE JOURNAL.

In reply to "F. F.," the sand should be new, floor sand not being suitable for clean work, and on the face it should be finely sifted, but the body of the mould does not require to be extremely fine. Facing sand is not necessary in many instances; but as extra smooth castings are required a little pea or bean meal should be mixed with the sand used for facing. Results as good may be had by dusting through a cloth some ground steatite over the mould and smoothing with a camel hair brush. The sand should be used as dry as possible, consistent with its use as a mould, and should be rammed as lightly as can be managed, the object being to secure a porous mould of only sufficient resistance to hold against the flow of the metal. Venting should be ample, it being necessary to get rid of the air and gases as rapidly as possible, as the metal runs up faint against air pressure.

C. E. ALLEN.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—Locality has much to do with determining what sand shall be used. For facing sand for aluminium ornaments, etc., use the greensand facing sand with the coal dust left out. This sand very finely sieved, and the mould dusted very lightly with Tara-flake, should give the desired result.

Yours, etc.,
"W. R."

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—In reply to "F. F.," I can firmly recommend Mansfield rock sand. The proportions to use are 1 part old sand to 3 parts new. This should be milled and run through a fine sieve for facing. Care must be taken not to pour the metal too hot, or rough casting will result, no matter how good the sand may be. If attention is paid to this point no extra facing will be necessary.

Yours etc.,
"H. H. T."

SWEDISH PIG-IRON.

Will "G. H. F." kindly favour us again with his address, as several readers wish to know the name of the makers of the pig-iron mentioned in last month's correspondence.

THE EDITOR.

NICKEL AND COPPER.

To the Editor of the FOUNDRY TRADE JOURNAL.

DEAR SIR,—We have lately been experimenting with a white metal mixture containing 50 parts nickel and 50 parts copper. We find it a very difficult matter to get the nickel melted. In fact, we are unable to do so thoroughly. We use No. 100 ordinary plumbago crucibles with the common brassfounders' furnace. Can you recommend any method for getting the nickel quickly into a fusible state?

We may say we have had the nickel in the crucible for over six hours, and at a *white heat* nearly all this time, and still it didn't melt.

Yours, etc.,
"NICKEL."

TROUBLE WITH ALUMINIUM ALLOYS.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—I am making aluminium alloy castings, such as radiators, oil tanks, engine bed covers, etc., and on the face of these castings there appears a kind of skin crack. The moulds are made in ordinary brass sand, dusted with plumbago and white dust mixed and smoothed up. The alloy is run at a blood-red. The castings are got up as soon as they are set. I have tried feeding them and leaving them in the moulds till cold, but still there appears the mark on the face of them.

Also I have a quantity of aluminium alloy castings to burn up, but I cannot get the alloy to burn. Can you give me any information that will help me with these difficulties?

Yours, etc.,
"H. S."

VERTICAL-CAST PIPES.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—Thickness has the greatest influence for good or evil in the casting of vertically-poured pipes. Assuming "Remedy's" trouble is confined to absolute clean faces at both ends, and that we are dealing with a vertically-cast dry

sand pipe, the cure for speckled or otherwise defective faces on the top end of those pipes is in having a duly proportioned sinking-head. It is really not so much a question of the vertical depth or the length of the sinking-head, as it is a case of what metal is required in the section of same. There are many ways of treating vertical-cast work, and for this each casting poured thus must have its own particular sinking-head, which can only be determined from long practice and observation. Briefly, with all things normal, this defectiveness on the top ends of vertical-cast pipes accompanies, to a greater or lesser extent, all moulds that are cast vertically, no matter with what sort of metal they be cast. There is no iron as yet discovered capable of assimilating dirt, or mitigating draw or shrinkage on the top ends of castings that are vertically poured. Nothing but a duly proportioned sinking-head that is capable of receiving the kish and dirt accumulated through the process of pouring, as well as the last part of the casting to set, and in some cases the aid of the feeder as well, will overcome the dirt. Of course, feeding in vertically-cast pipes is not in keeping with pipe practice.

Yours etc.,
"W. R."

——o——

PERSONAL.

MR. J. E. PETAVEL has been appointed to the Chair of Engineering in Manchester University.

THE late Mr. T. Lees, of Messrs. T. & R. Lees, ironfounders, etc., left estate of the gross value of £38,068.

THE late Mr. G. Cannings, ironfounder, of Rosemount, Rowlands Castle, Hants, left estate of the gross value of £9,320.

MR. J. GALLOWAY, commercial manager and partner in the firm of Ross & Duncan, Whitfield Works, Govan, N.B., has retired.

THE gross value of the estate of the late Mr. J. C. Wood, of Blackwood & Wood, engineers nad boiler-makers, Liverpool, is £7,467.

MR. T. BROWN has retired from active participation in the management of Burys & Company, Limited, and remains in a consultative capacity only. His eldest son, Mr. H. W. Brown, has been appointed general manager, and Mr. J. T. Miller secretary.

TRADE TALK.

MESSRS. B. ATKINSON and W. ROBINSON, brassfounders, Keighley, have dissolved partnership.

MESSRS. C. LYNEX and H. DUTTON, malleable ironfounders, etc., Walsall, have dissolved partnership.

WILLANS & ROBINSON, LIMITED, have decided to sell their leasehold interest in the Ferry Works, Queensferry, Flintshire.

DAMAGE estimated at nearly £20,000 has been done by fire at the engineering works of Messrs. Wenham & Waters, at West Croydon.

MESSRS. H. PULLEN, A. GILL, and W. GRANGE, brassfounders, etc., Bradford, trading as Foster & Pullen, have dissolved partnership, so far as regards Mr. A. Gill.

A DISSOLUTION of partnership is notified in connection with Messrs. J. G. Hadley and A. E. Hadley, brass and ironfounders, Cakemore, near Blackheath, Worcestershire.

THE CASTLE WORKS, Hadley, Shropshire, formerly in the occupation of the Electric Railway and Tramway Carriage Works, Limited, are being offered for sale by private treaty.

THE BRITISH MANNESMANN TUBE COMPANY are having a surface condensing plant installed at their works, the order having been placed with the Mirrlees Watson Company, Limited.

AT the Cardiff Bankruptcy Court, recently, Mr. E. A. Grey, Maesteg Foundry and Engineering Works, Maesteg, appeared for his public examination. Bankrupt's statement of affairs showed liabilities amounting to £552 2s., and his deficiency to £494 3s. 11d. The examination was provisionally closed.

THE following tenders were recently sent in to the Burnley Rural District Council for the supply of cast-iron pipes:—British Mannesmann Tube Company, London, £598; Cochrane & Company, Dudley, £586; Stanton Iron Works Company, near Nottingham, £564; J. Oakes & Company, Alfreton, £562; J. & D. Ritchie, Middlesbrough, £560; Clay Cross Company, Chesterfield, £560; Cochrane & Company, Middlesbrough, £554; Holwell Iron Company, Asfordby, £552; Staveley Coal and Iron Company, Staveley, £542; J. Shaw & Company, Glasgow, £537; Sheepbridge Coal and Iron Company, Sheepbridge, £536.

THE HOLWELL IRON COMPANY, LIMITED, who held the Metropolitan Water Board's

contract during 1907-8 for the supply of cast-iron pipes to the New River, Southern and Western districts, recently informed the Board that they had a certain surplus of pipes and castings made under their contract over and above the actual orders received, and enquired whether the Board would purchase them at the following rates:—Specials, green sand castings, £9 10s. per ton; specials, loam sand castings, £10 10s. per ton; straight pipes at contract prices for 1907 for the district for which they may be required. These prices compared favourably with those under the existing contract, and the Works and Stores Committee therefore recommended that authority be given for the purchase from the Holwell Iron Company, Limited, of their pipes and special castings at the following rates:—Specials, £9 10s. per ton; straight pipes at the prices quoted by the company in their contract with and accepted by the Board for 1907-8.

——o——

NEW COMPANIES.

Bosshardt Casting Process, Limited.—Capital, £10,000. Registered office: 11-12, Royal Exchange Chambers, Leeds.

Daniel Smith, Limited.—Capital £5,000, to carry on the business of engineers, etc., and to adopt an agreement with D. Smith.

Hermann Wedekind, Limited.—Capital £2,000, to carry on the business of engineers, etc. Registered office: 110, Fenchurch Street, E.C.

Giles & Ward Foundry Company, Limited.—Capital, £6,000, to acquire the undertaking of the Giles & Ward Foundry Company (incorporated in 1902).

Briddon & Fowler, Limited.—Capital £50,000, to carry on the business of engineers, etc. Registered office: Engineering Works, Bredbury, Cheshire.

E. & W. H. Haley, Limited.—Capital £5,000, to carry on the business of ironfounders, etc. Registered office: New Foundry, Lister Hills, Thornton Road, Bradford.

H. H. Green & Russell, Limited.—Capital £20,000, to take over the business of latch, bracket, and general oddwork manufacturers, malleable soft grey and general ironfounders, etc., carried on at Thomas Street and Nelson Street, Church Lane, Wolverhampton, as H. H. Green & Russell.

DEATHS.

Mr. C. F. Greene, brassfounder, of Leeds, aged 59 years.

Mr. H. Box, owner of the Marhamchurch Foundry, Bude, aged 69 years.

Mr. J. Smyth, the founder of the firm of James Smyth & Sons, Peasenhall.

Mr. E. Fletcher, a director of the Campbell Gas Engine Company, Limited.

Mr. J. A. Stephenson, formerly rolling-stock controller on the North-Eastern Railway.

Mr. Harris Tabor, of the Tabor Manufacturing Company, Philadelphia, inventor of the Tabor moulding machine and many other mechanical appliances, died recently at the age of 65. Mr. Tabor was born in Clarence, Erie County. As a boy he was of a studious and inventive turn of mind, and in after life those traits, together with excellent ability as an executive, marked his career. His mechanical training started when he was an apprentice in the shop of his brother, Leroy Tabor, Sr. In 1883 he went to Pittsburg as superintendent of the Westinghouse Machine Company, remaining with that company about two years. It was during his services with the Westinghouse Company that he conceived the idea of inventing a moulding machine that should be operated by power. He associated himself with Messrs. Manning, Maxwell & Moore to develop and perfect the device, and the Tabor Manufacturing Company was organised for the purpose. In 1888, Mr. Tabor put the first successful moulding machine on the market. It was operated by steam power with an overhead cylinder. The building of these machines was then given to the Pond Tool Works, Plainfield, N.J., and continued there until the early 90's, when the manufacture was transferred to Messrs. Samuel L. Moore Sons Company, Elizabeth, N.J. It was here that he brought out vibrator moulding, and built the first machine operated by compressed air. The Tabor moulding machine was introduced by him in this country upon an extensive scale, and it is now quite widely used. In 1900, Mr. Tabor sold out the greater portion of his interest in the company to Wilfred Lewis, and the plant was subsequently moved to Philadelphia. Mr. Tabor was president of the company up to that time, and was a member of the American Society of Mechanical Engineers.

FOUNDRY LADLES.

28 LB.
—to—
30 TON.

JAMES EVANS & CO., BRITANNIA WORKS,

TELEGRAMS—
"LADLES, MANCHESTER."
TELEPHONE—2207

BLACKFRIARS, MANCHESTER.

LIST OF NEW INVENTIONS.

Specially compiled for the FOUNDRY TRADE JOURNAL by MR. GEORGE BARKER, Fellow of the Chartered Institute of Patent Agents, 77, Colmore Row, BIRMINGHAM.

1908.

15,685. A. HIRSCHEL. Improved metal-carrying trough.

16,428. HANS MENNICKE. Process for preparing, smelting, and utilising various products containing tin, particularly the metallic sponge and slime obtained in the electrolytic removal of tin from tinplate scrap.

16,521. L. S. HUGHES. Improvements in metallurgical furnaces.

16,709. T. WILLIAMS, and SOUTH DURHAM STEEL AND IRON COMPANY LIMITED. Improvements in ingot moulds.

1907.

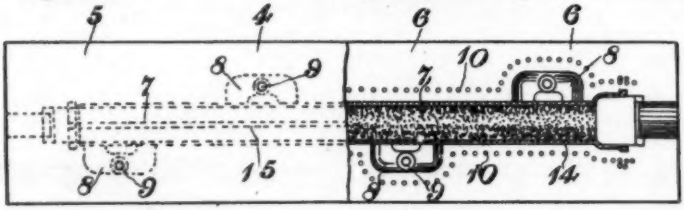
16,748. E. A. CUSTER, Philadelphia. Improvements in moulds for casting pipes, and the like.

This invention relates to moulds for casting pipes, and the like, such as water or soil pipes, from molten metal.

The object of the invention is to provide a mould by which a cast metal pipe, or the like, can be produced ready for use without further finishing, and without blow holes and other imperfections, such as shot formations upon the exterior surface.

As shown in the figure, which shows a plan of a permanent mould with part broken away, 4 is a mould of rectangular form, made of material such as metal. The mould consists of a cope 5 and drag 6, and each provided with a semi-circular depression 7, which, when the cope is placed on the drag, form an annular chamber of the contour or outline of a pipe.

The surface of the chamber being of an unyielding material, and smooth, will impart to the metal introduced into the mould a smooth or even surface throughout, and thus the structure cast will not require finishing when removed from the mould. The cope 5 is provided with pour holes 9, extending through the same and registering with the series of gates 8 of the drag. In order to allow for expansion of the metal and the mould, small openings 10 are provided, extending into



the body of the drag and cope; these avoid cracking of the mould. The core consists of a perforated hollow body 13, similar in outline to the depressions 7 of the cope 5 and the drag 6, but of smaller diameter. The grooves extending along the length of the drag are filled with mica, and these are found to give a smooth face to the metal which comes in contact with it.

The channel 15 is arranged to collect and liberate the gases rising from the mould, and the metal is poured in through pour holes 9 in the gates 8.

Ganister, Cupola Blocks, Fire Bricks,
Fire Clay.
Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.
Steel Moulders' Composition, Silica Cement.

J. GRAYSON LOWOOD & Co., Ltd.,
DEEPCAR, nr. SHEFFIELD.
Telegrams: "LOWOOD, DEEPCAR."

PATENT

ALUMINO THERMIC WELDING PROCESS

REG. TRADE MARK.

— FOR —

BROKEN CASTINGS.

REPAIR SHOP

NOW OPEN.

ESTIMATES for WORK and ILLUSTRATED PAMPHLET upon application to

THERMIT LIMITED,

27, MARTIN'S LANE, CANNON STREET, E.C.

ELDERS FOUNDRY COKE

As supplied to the British . . Admiralty Dockyards.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.

We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blow-holes and other defects, than we formerly did.

From MOUNTFORT PHILLIPS & Co., Llantrissant.

Llantrissant, October 25th, 1904.

In reference to the Foundry Coke you have been supplying us with for the last six months, we have very great pleasure in letting you know that it has given every satisfaction, and that our Works Manager and Workmen give it the highest praise.

Elders Navigation Collieries, LTD. Cardiff.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years :—

Metals.	1907-8.	1906-7.
Iron—Scotch pig warrants ... ton	..... *56 6	..... *65/0
—Middlesbro' warrants ... ... ton	..... 51 9	..... 56/9
—W.C. M/nos Bessemer ... ... ton	..... 58 0	..... 80/6
—Stock, Scotch, tons	 1,000	 1,860
Copper—Chill bars, GMB ... ... ton	..... £60 10 0	..... £79 7 6
—Stock, Europe & afloat... ... tons	 44,785	 14,232
Tin—English ingots ton	..... £133 2/6	..... £172 10 0
—Straits ... ton	..... £133 7 6	..... £169 15/0
—Stock, Ldn. Hind and afloat ... tons	 16,304	 13,183
Lead—English pig ton	..... £13/16 3	..... £20 0 0
Spelter—Ord. Silesian ... ... ton	..... £19 5 0	..... £21 15 0
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,, 3 to 4 in.	4 15 0	to	5 5 0
,, 5 to 8 in.	4 12 6	to	4 15 0
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,, 18 to 24 in....	4 12 6	to	4 15 0
Chairs	3 10 0	to	3 15 0
Floor plates (open sand)	3 2 6	to	3 5 0

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The quotations for scrap, subject to market fluctuations, are as follows:—Heavy wrought (mixed), £2 5s. 0d.; light wrought, £1 1s. 0d.; heavy cast, £2 6s. 0d.; all per ton f.o.b., London. Copper (clean), £53 0s. 0d.; brass (clean), £39 0s. 0d.; lead (usual draft), £12 10s. 0d.; tea lead, £10 15s. 0d.; zinc, £15 5s. 0d.; all per ton delivered merchant's yard.

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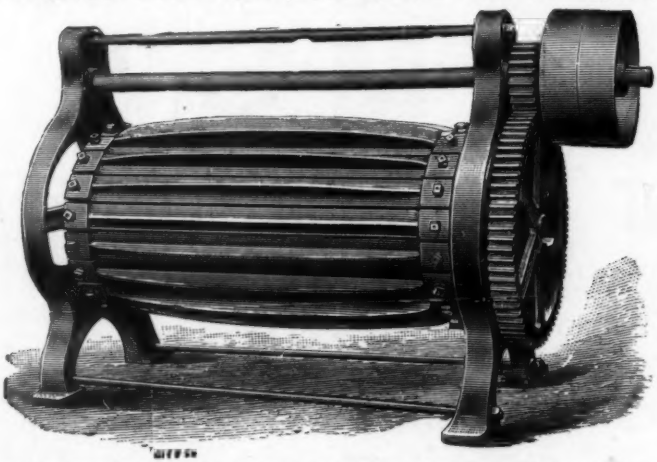

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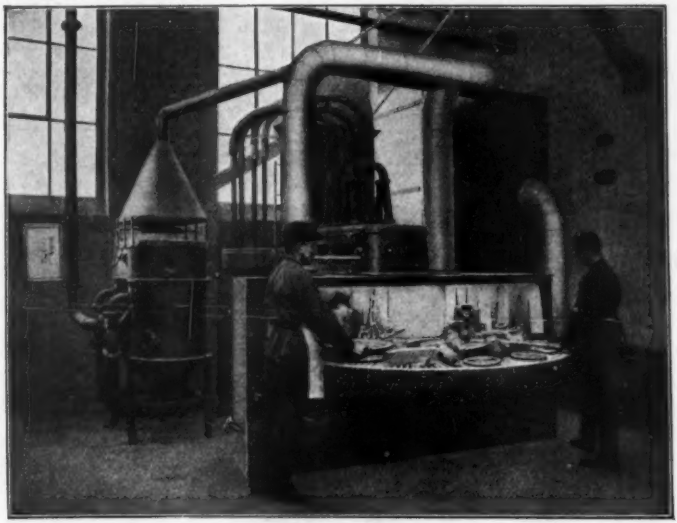

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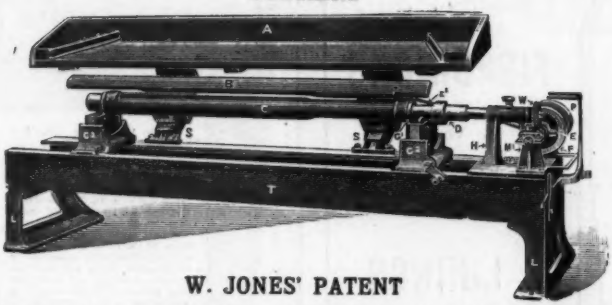

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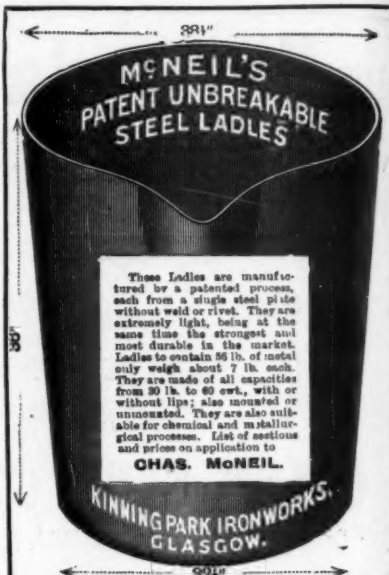
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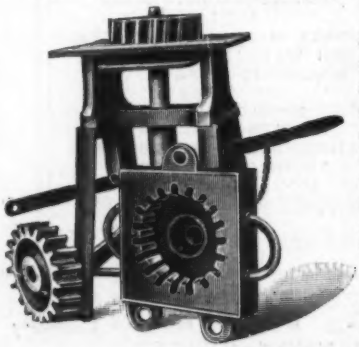

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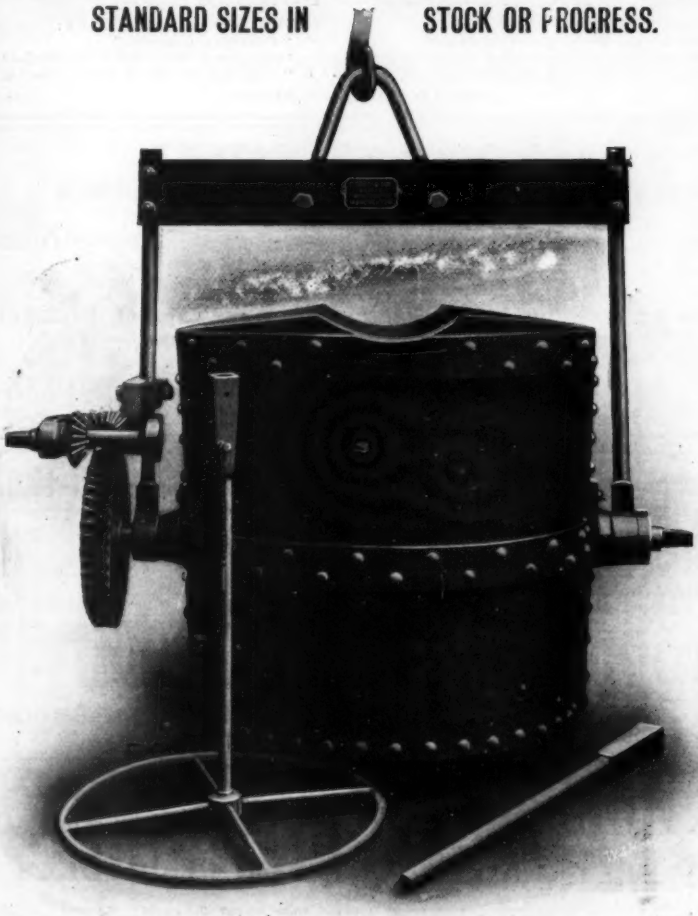

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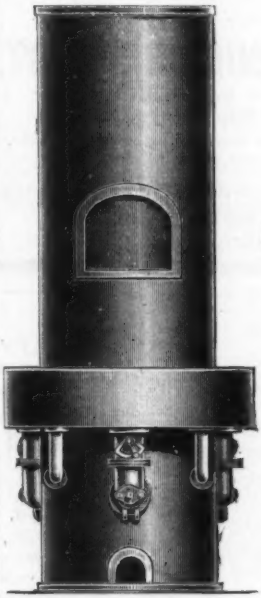

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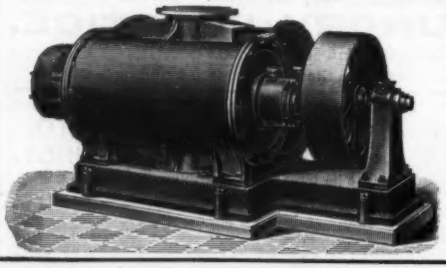

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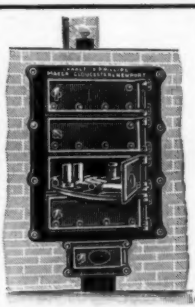

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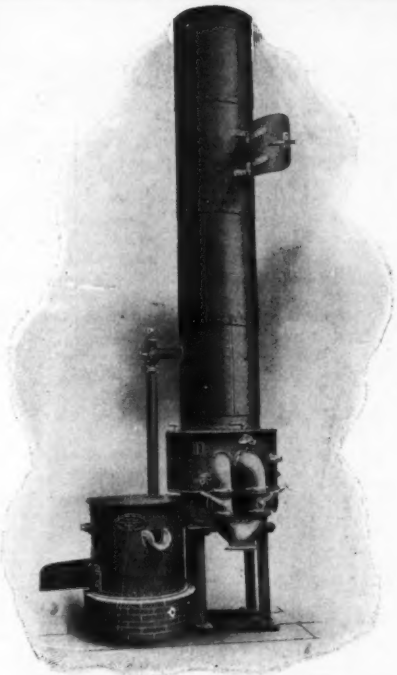

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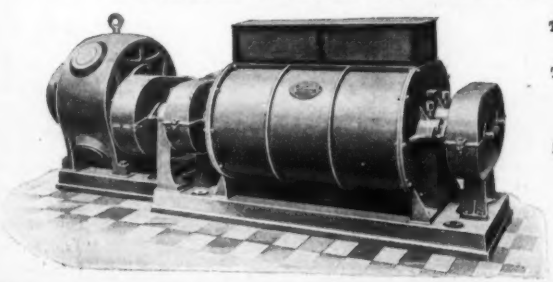

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